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ABSTRACT

This document is one in a series distributed by the Agricultural Extension Service of the University of Wyoming-Laramie. It provides an introduction to pesticides and is concerned with pesticide development, labeling and safety associated with the use, storage and disposal of these substances and their containers. Safety aspects of handling and using pesticides are stressed. Information is presented on selecting, mixing and applying various formulas. Additionally, pesticide effects and symptoms are discussed with guidelines for treatment of and antidotes for pesticide poisoning. A glossary of terms is included for reference. (CS)

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Introduction To Pesticides

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INTRODUCTION TO PESTICIDES

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Laramie, Wyoming

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INTRODUCTION TO PESTICIDES

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SECTION I

INTRODUCTION

To man, probably no greater effort is more universal or more characteristic than the constant battle with pests. The need to increase food supplies, improve living conditions, and prevent health problems has been man's goal throughout his existence. Man has strived to attain this goal by developing effective methods for pest control.

Over the past few decades, research scientists have made remarkable progress in the area of pesticide development and use. Prior to the early 1940's control of pests in agriculture and health related problems was largely dependent on relatively simple chemical compounds developed in the nineteenth century. Methods to obtain effective pest control were present during World War II to protect man against pest-carried diseases such as malaria, typhus, sleeping sickness, and yellow fever. Undoubtedly the war years catalyzed the development of pesticides and contributed to the steadily improved, sophisticated pesticides in use today.

What are pests? Pests are those organisms that are undesirable. They compete for food, cause injury, or can be annoyances. Most familiar are probably insect pests; however, weeds, fungi, viruses, bacteria, rodents, and other organisms can be as destructive as insects when left uncontrolled.

A pesticide can be described as any chemical used to kill, control, or diminish a pest population that threatens the well being of man. Most commonly pesticides are divided into several categories, depending upon the pest to be controlled.

Herbicides can be used to control unwanted plants either selectively or generally.

Insecticides are used for protection of growing and stored crops against insect damage and destruction. They are also used worldwide to protect people and animals from annoying or disease transmitting insects.

Fungicides are most commonly used to protect plants or seeds from infection by fungi causing molds, rots, and blights.

Rodenticides are used to control rodent pests such as rats and mice.

Nematicides are used to control worm-like microscopic organisms called nematodes that usually live in the soil and feed on underground portions of plants.

Molluscicides control snails and slugs.

Is there a pest problem? It has been estimated that there are 850,000 species of insects, and 10,000 of these are classified as enemies. There are some 2,600 weed species of which 600 are known to cause economic losses. Add to this the pests involved with causing plant diseases such as fungi, nematodes, bacteria, and viruses and the problem appears to be insurmountable. Select just one of these pests -- insects. There are more insects in the world than any other living thing. As the world population increases, the competition with insects and other pests for available food and fiber will become more intense.

Farmers have learned to become more efficient. Pesticides and fertilizers combined with major advances in farm mechanization and greatly improved plant varieties have enabled farmers to achieve very high increases in productivity during the twentieth century. The loss margin farmers can absorb due to pest problems in production costs becomes less each year. It has been estimated without pesticide use, crop and livestock output would be reduced by about 40%. This would indicate that foreign exports would be eliminated and prices of food would at least be doubled.

Household pests are still another kind of pest problem. Not everyone is prepared to do without attractive lawns, beautiful flower beds, and pest-free households. Trees are also susceptible to a wide variety of pests. During recent years tree defoliation caused by insects has resulted in irreparable damage in suburbs and in forests. When such damage occurs in forests, the result is loss of habitat for birds and other wildlife.

SECTION II

PESTICIDE DEVELOPMENT AND REGISTRATION

The number of new pesticides being released from the agricultural chemical industry has been drastically reduced during the past few years for the following reasons: the demand placed on the chemical industry to maintain registration of existing products; the uncertainty of future legislation and restrictions regarding the use and registration of pesticides; and the high costs of registering a new pesticide under present governmental requirements. It is the high cost of obtaining the initial registration and the long period before dividends can be expected on the investment that has caused many pesticide manufacturers to curtail and, in some instances, completely cease research and development.

Many scientific disciplines are involved in the process of researching a new pesticide. Scientists working in the areas of chemistry, entomology, weed science, biology, physiology, toxicology, ecology, pathology, and others are involved in the development of a pesticide. It has been stated that probably no other product in any other industry requires as much time, money, and scientific information in order to meet the requirements to obtain approval for public sale as does a pesticide. A recent survey has estimated that it takes on the average seven years to develop a pesticide ready to market. There are many procedures involved in developing a new pesticide compound. A brief discussion of each stage of development is in order.

Market Analysis

The pesticide manufacturer conducts a market study to determine if there is need for a new compound. The new product when developed, should warrant use to justify the expenditures to develop and produce it. The greater the potential uses for a new product, the more likely it is to be developed. Only if it is needed will a company spend time and money on research to produce it.

Synthesis

The company will design the pesticide's structure and conduct a literature review to determine if similar materials have been developed. The new compound will be synthesized and preliminary screening will be conducted to determine its activity for pest control. It has been estimated that only one new compound in over 7,000 will survive the initial stage of screening. If the material shows promise it will be further characterized and purified. Some cost estimates will be made by the developer to resolve the cost to manufacture it. During the process of synthesis, initial toxicology studies will be conducted to determine the toxicity levels or LD_{50} values to laboratory animals.* If the initial greenhouse screening indicates the compound has promise the next step is process development.

Process Development

The manufacturer will conduct an initial study to determine the difficulty of processing the new pesticide. Test samples will be prepared to conduct further field evaluations of the pesticide's potential. At this time, or stage of development, plans are made to set up a pilot plant to produce the material. More advanced studies will be conducted in detail to determine the difficulties in the manufacturing processes and engineering designs for the future commercial plant.

Formulations

At this stage of development, the physical and chemical properties of the pesticide must be evaluated. Formulations of the pesticide must be studied to determine how the product can be marketed such as a liquid, wettable powder, granule, etc. These various formulations must undergo stability tests to evaluate storage life and suitable container design.

Initial Field Testing

Samples of the new pesticide are sent out for field testing on small plots or field screening trials to determine the activity and selectivity of the formulated compound under actual conditions in which it will be used. Field testing is conducted to confirm initial greenhouse screening trials and provide more reliable data on the possible potential of the material. At this point, the manufacturer must make a decision as to whether the compound is worth committing large sums of money for further development processes which are conducted concurrently. If the decision is "go", the next step is to conduct metabolism studies.

Metabolism

The parent compound must be isolated and identified after application of the material. Any metabolites or metabolism product of the altered parent material must be identified, located, and determinations of the amount present computed. From this point, toxicology and analytical method studies can be conducted.

Toxicology

This stage of development has become increasingly more detailed due to additional governmental registration requirements to protect the environment. Oral, dermal, and inhalation toxicity tests must be conducted on small laboratory animals. The effects of the pesticide on man, fish, and wildlife must be determined. Studies are initiated to conclude the pesticide's effects on reproduction processes and determine if it has the potential of being mutagenic or teratogenic.

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* See page I - 35 for explanation of LD_{50}.

Advanced Field Testing

Extensive field testing is initiated to establish rates of application, methods of application, and collect performance data. The new pesticide compound is sent to state universities for their evaluations and recommendations. Oftentimes, an experimental label is obtained so data can be collected under actual grower use conditions to support the petition for registration. Residue samples are obtained and analyzed to support petitions submitted to the EPA (Environmental Protection Agency) to establish tolerances. After advanced field testing is conducted, the new pesticide must be extensively reviewed from the environmental standpoint.

Environmental Studies

There are many factors to consider environmentally when developing a new pesticide. Research data must be collected to determine the residual life of the pesticide in soil. The effect of leaching and run-off is of prime importance. Subsequent cropping after pesticide treatments must be evaluated. When the pesticide is used, determinations must be made as to its effect on non-target organisms and wildlife. Many detailed studies are required to collect data on pesticide biomagnification in the environment.

Analytical and Residue Studies

A means or method of pesticide analysis must be developed to determine residue levels. A standard analytical method is arrived at for every pesticide before crop, animal, and other environmental samples can be analyzed for the parent compound and its metabolites. The residue sample determinations are used to support label registrations and tolerance petitions submitted to the EPA for clearances. Routine samples of the pesticide are analyzed by the manufacturer and various other regulatory agencies for quality control.

Regulatory Activities

Following all of the stages of development previously discussed, the information is organized and summarized in the proper form to submit to the EPA to obtain initial registrations and tolerances. Labels are printed after clearances are approved and the pesticide is ready for market.

SECTION III

PESTICIDE LABELS

Man has been and will continue to use pesticides to control troublesome insects, weeds, plant diseases, rodents, and other pests. The key to using pesticides safely and effectively is the label. The information found on a pesticide label is the result of several years of extensive research and development that has cost several millions of dollars. The importance of reading the label cannot be over emphasized. The information that is found on the label is there to inform and protect the pesticide user. If the label is read and understood and all of the directions for use are followed, it is very unlikely the pesticide will be misused or be the cause of an accident. It is often stated that a pesticide label is the most expensive literature available to read.

The label has the information and instructions necessary for the efficient and safe use of the pesticide. The label, by law, is required to include the following:

1) Product or brand name.
2) Percentage of active ingredient.
3) Percentage of inert ingredient.
4) Intended use of product.
5) Directions for use --
    Pests to be controlled.
    Crops, animals, or sites to be treated.
    Rates, how, and when to apply.
6) Warnings --
    To protect pesticide user.
    To protect consumer of treated foods.
    To protect man, animals, and desirable plants.
    To keep out of reach of children.
7) Net weight or measure.
8) Name and address of manufacturer or registrant.
9) Environmental Protection Agency registration number.

You should read the label before purchasing, mixing, applying, storing, or disposing of a pesticide.

1) Read the label before purchasing the pesticide to determine if it will do the job. Never select and purchase a pesticide on the basis of label color. Many labels may be identically colored and contain completely different active ingredients. The label

will indicate if the material is too toxic or hazardous to use under certain conditions. The percentage of active ingredient or concentration must be known to determine the amount needed.

2) Read the directions before mixing to determine if protective equipment is necessary. Warnings and antidotes will be described when required. Information is available in regard to what materials the pesticide can be mixed with, how to mix it, and how much to use.

3) Read the label before applying to determine the safety measures to be followed by the applicator. The methods of application are described as to how, what, when, and how much pesticide can be used. Restriction of use such as waiting periods, reentry periods, and other special instructions are found on the label.

4) Read the directions before storing the pesticide to determine where, how, and where not to store the material for safe keeping.

5) Read the label before disposing of leftover pesticides and containers to determine the means of container decontamination and the proper site of disposal.

There are several key words or symbols found on pesticide labels that are required by law. Certain words such as "Warning", "Caution", "Danger", "Poison", and the skull and crossbones symbol are found on various labels. They are usually an indication of the pesticide's toxicity based on LD_{50} or LC_{50} values.*

The words "Danger", "Poison", and the skull and crossbones symbol are found on the label of highly toxic pesticides. The acute LD_{50} values of these materials range from 0 to 50 mg/kg.

The word "Warning" indicates the compound is moderately toxic with an acute oral LD_{50} range of 50 to 500 mg/kg.

Slightly toxic compounds have the word "Caution" on the label. These pesticides have an acute oral LD_{50} value that ranges from 500 to 5,000 mg/kg.

Pesticides that have acute oral LD_{50} values above 5,000 mg/kg have no special symbols or signal words on their labels. All pesticide labels must bear the statement, "Keep out of the reach of children." No label can make unqualified claims for the safety of a pesticide.

A few minutes spent reading pesticide labels is not wasted time. Based on years of research, the label combines field and laboratory knowledge of scientists whose main interest is not just to eliminate pests, but to do it safely.

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* See page I - 35 for explanation of LD_{50}.

The following sample label entitled "Don't Read This...Unless You Want to Understand Chemical Pesticides" represents a typical, though fictitious, label for a pesticide. Explanations and definitions are given for many of the usual terms and for the technical information found on pesticide labels.

SECTION IV

PESTICIDE SAFETY

A. Pesticide Poisoning and Effects

There are three ways that toxic chemicals may enter the human body to cause poisoning. The routes of exposure are as follows:

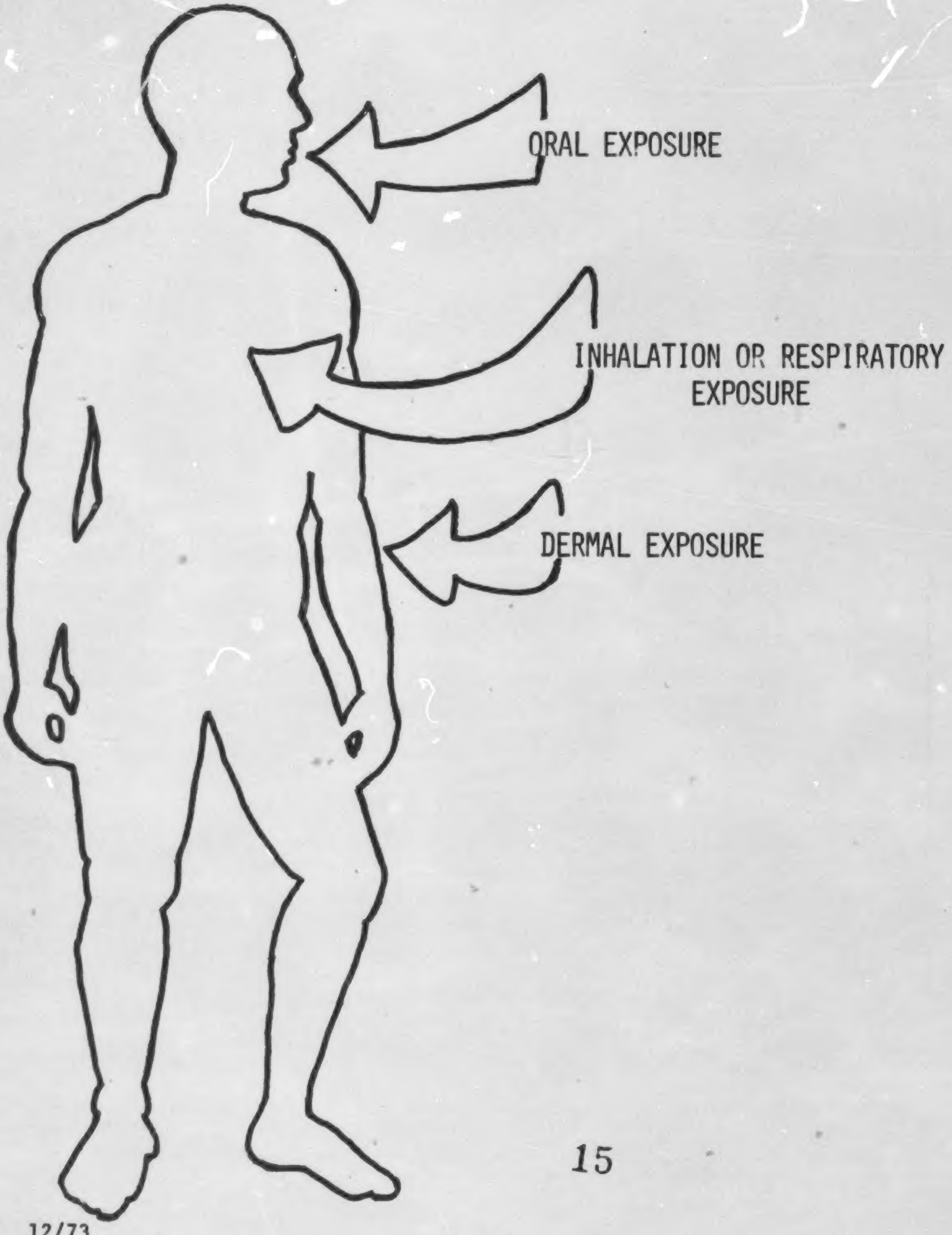
1) Dermal exposure (absorption through the skin). When some pesticides come into contact with the skin, a certain amount may be absorbed and enter the body.

2) Oral exposure (swallowing or gastrointestinal absorption). Eating or drinking the pesticide material.

3) Inhalation or respiratory exposure (absorption by breathing). Pesticides are absorbed through the lungs following the breathing of fumes, vapors, and dusts.

Dermal Exposure

Most sources of information report that pesticide absorption through the skin is the most common cause of poisoning in agricultural workers. Absorption through the skin may occur as a result of splash, spillage, or drift when pesticides are being measured, mixed, loaded, or applied. It may also occur upon contact with the deposit of residue remaining on the treated crop or site. There are several factors that effect dermal penetration of a pesticide, including: 1) physical and chemical properties of the pesticide; 2) health and condition of the skin; 3) temperature; 4) humidity; 5) presence of other chemicals (solvents, surfactants); 6) concentration of the pesticide; and 7) formulation type. All of these factors can affect penetration and absorption of a pesticide by the skin. The physical and chemical properties, concentration, formulation, and presence of other chemicals are established when a specific pesticide is selected for use. Temperature and humidity will be the conditions existing at the time of application, which are selected as weather conditions most favorable for effective pest control. The health and condition of skin may be variable at the time of pesticide application. Individuals with skin problems should avoid other than minimal exposures to pesticides, unless extra precautions are observed. Extra care should be taken to minimize pesticide exposure by those persons with cuts, abrasions, scuffs, scratches, or any other skin disruption.


ORAL EXPOSURE
INHALATION OR RESPIRATORY EXPOSURE
DERMAL EXPOSURE

DON'T READ ON........

..............unless you want to understand CHEMICAL PESTICIDES

With mounting success, man is using chemical pesticides to control troublesome insects, plant diseases, weeds, rodents, and other pests.

With each use, we make a careful selection--Which pesticide will do the job?

With each use, we make a vital decision--how do I use the pesticide?

With each use, we thoughtfully ask--how do I prevent misuse which could endanger the lives of humans, pets, livestock, fish, wildlife, and a host of beneficial plants or cause harmful effects on the total environment?

A few minutes spent reading pesticide labels is the best insurance we can have. Based on years of research, the label combines field and laboratory knowledge of scientists whose main interest is not just to eliminate pests, but to do it safely.

The sample label inside represents a typical, though fictitious, label for an herbicide. Explanations and definitions are given for many of the usual terms and for the technical information found on pesticide labels.

Don't read on . . . . unless you want to understand CHEMICAL PESTICIDES.

Written by A. F. Gale, Wyoming Extension Pesticide Specialist

DON'T
READ
THIS............

..........unless you want to understand

CHEMICAL PESTICIDES

PERCENT (OR POUNDS)—The percent of active ingredient in a pound of dry formulation (or the actual pounds of active ingredient in a gallon of liquid).

WETTABLE POWDER—Dry forms of the chemical in which the active ingredient or killing agent is absorbed in powder. Can be readily mixed with water and sprayed. Pesticide sprays are manufactured as emulsifiable concentrates, soluble powders, wettable powders, and liquids. Dusts and granules are used for dry applications. Aerosol bombs contain a pesticide and a propellant in a pressurized can.

PRE-EMERGENCE—The time of treatment, generally after planting the crop but before it emerges from the soil.

ANNUAL WEEDS—Plants that complete their life cycles from seeds to mature plants in one year.

STRIKE OUT®—The brand or trade name, generally a trademark, registered ® and used by only one company. Often the same chemical compound is sold by different companies under different trade names.

HERBICIDE—A chemical used for inhibiting the growth of or killing plants.

SELECTIVE HERBICIDE—A chemical compound that is toxic to or will kill one plant but not another.

WARNING—Read this part carefully. It is written for your protection and safety. Generally it gives the hazards of using the pesticide. Be sure to follow all directions and precautions in this section. Instead of a "warning," some pesticides have a "caution" statement and others are labeled "poison." Those products with warning or poison labels are more toxic than those labeled caution.

CONTAMINATION—To render food, water, seed, etc., unfit for intended use by allowing pesticide to come into contact with it.

ACTIVE INGREDIENT—That part of a chemical compound directly responsible for the control of the specific pest.

CHEMICAL DESIGNATION—Generally a complex and unpronounceable chemical name. Sometimes shorter names, coined from the chemical designation, become the common names. Accepted common names usually appear on the label.

INERT INGREDIENTS—That part of the chemical compound without toxic or killing properties. Sometimes called a carrier, it can be liquid or solid and generally is added to the compound to make it easier to use in the field.

GENERAL INFORMATION—This section covers the range of use of the pesticide. In this example it covers the weeds the herbicide STRIKE OUT will and will not control.

CONTROL—Does not necessarily mean eradication, but reduction of the pest problem to a point where it does not cause economic damage.

RATE—Rate and dosage mean the same. In most cases, however, rate is preferred. With wettable powders, emulsifiable concentrates, soluable powders, and liquids, rate is the amount of active ingredient applied to a unit (acre) regardless of percentage of active ingredient in the pesticide. For example, if local recommendations call for a rate of six pounds of active ingredient per acre, you would have to apply 12 pounds of STRIKE OUT per acre. STRIKE OUT is a 50 percent wettable powder, meaning that 50 percent of the dry formulation is active ingredient. In granular formulations, rate is stated as total pounds of the pesticide used.

HOW TO USE—This section tells how to use the pesticide—the amount of water to use, time of application, effects of soil and irrigation, spraying pressure, nozzle adjustment, and in this case, how to compute the amount of pesticide needed for band application. Other information may be provided in this section if it would affect the pesticide's performance.

TRANSPLANT—The act of moving a plant from one growing area to another (that is, greenhouse to field); or a plant which has been so moved.

P.S.I.—Pounds per square inch is the pressure at which spray equipment should be operated.

DRIFTING—Movement of the pesticide by air motion or wind. Do not confuse drifting with volatilizing which is the changing from a liquid to a gas upon exposure to atmospheric conditions (sun, wind, temperature).

BAND APPLICATION—An application to a continuous restricted area, such as in or along a crop row rather than over the entire field area.

LOCAL RECOMMENDATIONS—In most cases, application rates appearing on a pesticide label

CONTAINS 50 PERCENT WETTABLE POWDER

For pre-emergence control of certain annual weeds in only the crops listed.

STRIKE OUT
SELECTIVE HERBICIDE

WARNING: Harmful if absorbed through skin. Do not get on skin or in eyes. Do not take internally. To avoid contact with skin or eyes, wear rubber gloves and goggles when spraying or handling the wettable powder.

In case of contact, immediately wash skin with soap and plenty of water; for eyes, flush with plenty of water for at least 15 minutes and get medical attention.

Avoid contamination of seed, feed, or foodstuffs.

ACTIVE INGREDIENT: [illegible] carbamyl

INERT INGREDIENTS (Given as percent of carrier per pound).

Net Contents: 1 pound

GENERAL INFORMATION

STRIKE OUT controls these weeds:

Annual Bluegrass	Crabgrass
Barnyard Grass	Foxtail
Kochia	Pigweed
Chickweed	Purslane
Henbit or Blueweed	

STRIKE OUT will usually control lambsquarter at a rate of 6 pounds active ingredient per acre.

STRIKE OUT will not control perennial weeds, such as nutgrass, Johnson grass, quackgrass or Bermuda grass or broadleaf perennials such as white horse nettle, morning glory or possession vine. STRIKE OUT is recommended only for controlling certain annual grasses and broadleaf weeds in crops listed on our label.

HOW TO USE STRIKE OUT

Before using, refer to "Specific Crop Use" directions. STRIKE OUT is designed for application after mixing with water.

STRIKE OUT should be applied at planting time or prior to emergence of the crop and weeds.

STRIKE OUT also may be applied to [illegible] or on certain crops following clean cultivation. (See details under Specific Crop Use.)

STRIKE OUT works best on soils that are "light" and are low in clay. The seed bed should be well worked, firm and free of clods or trash. Do not disturb the soil surface unnecessarily after application.

Spray STRIKE OUT at pressures from 20 to 40 psi using flat fan-type nozzles. Higher pressures or cone type nozzles will cause loss of the chemical by drifting.

STRIKE OUT is not recommended for use with furrow irrigation. See STRIKE OUT Granular label for use recommendations under furrow irrigation.

FOR OVERALL APPLICATION spray uniformly after mixing STRIKE OUT with at least 20 gallons of water per acre.

FOR BAND APPLICATIONS reduce the amount of STRIKE OUT and water in proportion to the area treated. Mount spray equipment and adjust nozzle height in the field to spray the desired band width. Use nozzles designed for band spraying. (Even Spray or "E" series). Calculate the amount of STRIKE OUT needed per acre as follows:

$$\frac{\text{Band width}}{\text{Inches between crop rows}} \times \text{Amount needed for overall treatment} = \text{Pounds active ingredient of STRIKE OUT needed per acre for band applications.}$$

Example: If 4 pounds active ingredient per acre are recommended for overall treatment and you wish to apply a 12-inch band on rows or beds spaced 40 inches apart—$\frac{12}{40} \times 4 = 1\frac{1}{5}$ pounds active ingredient of STRIKE OUT needed per acre for this band treatment. The recommended rates for specific crops should be considered as general.

Consult competent agricultural authorities for best recommendations regarding dosages and methods of application.

[illegible]

ATTENTION

To prevent irritation of skin and eyes, use extreme care when handling or spraying STRIKE OUT. Following accidental skin contact, wash off the area of contact immediately with soap and warm water.

If allowed to remain in contact with the skin, STRIKE OUT in full strength or in spray may cause temporary loss of sensation locally. During application spray mist may drift, causing watering and irritation to the eyes. Goggles worn during application will minimize this hazard.

Promptly change clothing which becomes wetted by accidental spillage or drift from spray. Wash clothing before reuse. Wear rubber gloves if it is necessary to make repairs on the sprayer.

Keep container closed when not in use.

Spray equipment must be properly calibrated to avoid either over or under treatment. Before spraying, check all hose connections to see that they are firmly secured.

Do not use in any manner other than recommended on the label to avoid possible crop injury or residues at harvest.

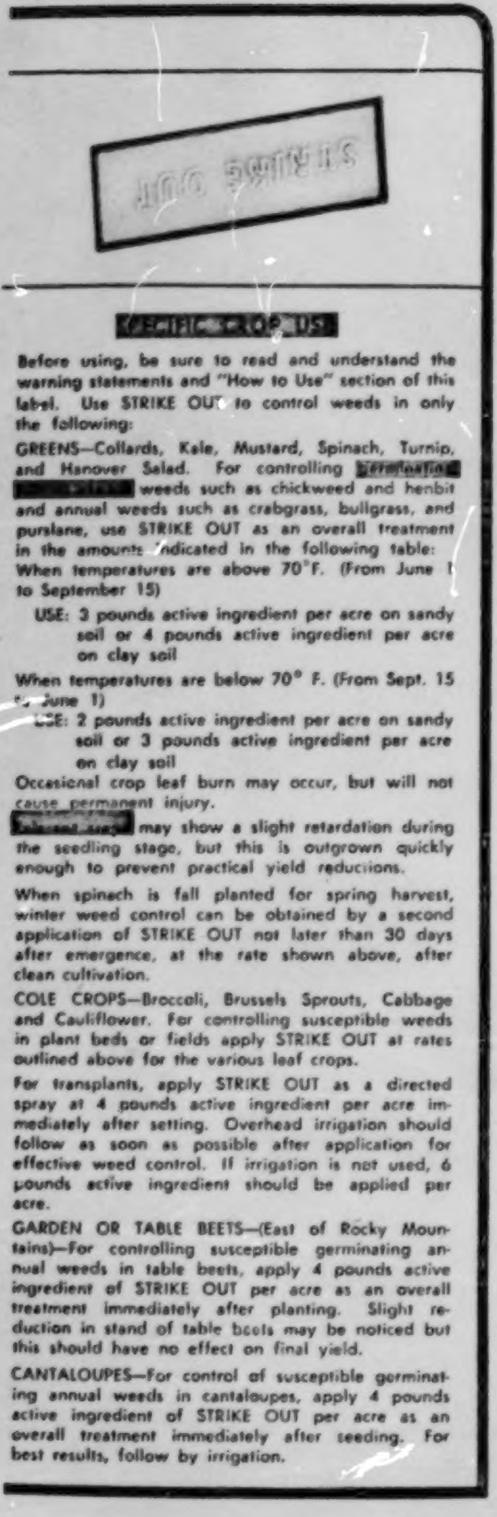
NOTICE TO BUYER

STRIKE OUT Chemical Company warrants that this material conforms to the chemical description on the label and is reasonably fit for use as directed hereon. STRIKE OUT Chemical Company neither makes, nor authorizes any agent or representative to make, any other warranty or guarantee in regard to this material.

The information found on the label is based on data which are believed to be reliable. It is understood that all such information is not guaranteed by STRIKE OUT Chemical Company to be accurate and is to be used at the risk of the user of such information.

STRIKE OUT Chemical Company
Somewhere, USA
Agricultural Chemical Division

STRIKE OUT



SPECIFIC CROP USE

Before using, be sure to read and understand the warning statements and "How to Use" section of this label. Use STRIKE OUT to control weeds in only the following:

GREENS—Collards, Kale, Mustard, Spinach, Turnip, and Hanover Salad. For controlling germinating [illegible] weeds such as chickweed and henbit and annual weeds such as crabgrass, bullgrass, and purslane, use STRIKE OUT as an overall treatment in the amounts indicated in the following table:

When temperatures are above 70°F. (From June 1 to September 15)

USE: 3 pounds active ingredient per acre on sandy soil or 4 pounds active ingredient per acre on clay soil

When temperatures are below 70° F. (From Sept. 15 to June 1)

USE: 2 pounds active ingredient per acre on sandy soil or 3 pounds active ingredient per acre on clay soil

Occasional crop leaf burn may occur, but will not cause permanent injury.

Tolerant crops may show a slight retardation during the seedling stage, but this is outgrown quickly enough to prevent practical yield reductions.

When spinach is fall planted for spring harvest, winter weed control can be obtained by a second application of STRIKE OUT not later than 30 days after emergence, at the rate shown above, after clean cultivation.

COLE CROPS—Broccoli, Brussels Sprouts, Cabbage and Cauliflower. For controlling susceptible weeds in plant beds or fields apply STRIKE OUT at rates outlined above for the various leaf crops.

For transplants, apply STRIKE OUT as a directed spray at 4 pounds active ingredient per acre immediately after setting. Overhead irrigation should follow as soon as possible after application for effective weed control. If irrigation is not used, 6 pounds active ingredient should be applied per acre.

GARDEN OR TABLE BEETS—(East of Rocky Mountains)—For controlling susceptible germinating annual weeds in table beets, apply 4 pounds active ingredient of STRIKE OUT per acre as an overall treatment immediately after planting. Slight reduction in stand of table beets may be noticed but this should have no effect on final yield.

CANTALOUPES—For control of susceptible germinating annual weeds in cantaloupes, apply 4 pounds active ingredient of STRIKE OUT per acre as an overall treatment immediately after seeding. For best results, follow by irrigation.

are general. For many areas these rates may differ. For local rates, consult your local or state pesticide recommendations.

EPA (Environmental Protection Agency) REGISTRATION NUMBER—All pesticides sold in interstate commerce must be registered with the Environmental Protection Agency. The registration number, which must appear on the pesticide label, guarantees the buyer that the material has been approved by the EPA for the uses stated on the label. Many states, including Wyoming, have a law that pesticides must be registered with the State Department of Agriculture.

ATTENTION—This section provides detailed information on preventing bodily harm, should pesticide use be hazardous. It may include a discussion of protective measures such as rubber gloves, goggles, and other clothing to be worn while mixing and applying the pesticide. Labels suggest first aid procedures and antidotes should the pesticide be taken internally and cause accidental poisoning.

HAZARD—A word indicating the possibility of injury should the pesticide be misused.

CALIBRATED—Set to deliver a specific amount of spray mixture for each unit (square rod or acre). Applies to both spray rig or granular distributor.

RESIDUES—The pesticide remaining on or in a treated product. Some labels declare a time interval, usually in days, which must lapse between pesticide application and harvest.

NOTICE TO BUYER—Manufacturer's statement declaring the extent of product guarantee or warranty and the responsibilities of users.

CHEMICAL COMPANY—The name and address of the manufacturer. The law requires this information to be on the label.

SPECIFIC CROP USE—Specific instructions regarding areas where the pesticide may be used, rate of application, and other information on proper use.

GERMINATING—Beginning to sprout, grow or develop.

WINTER ANNUAL—Plant that germinates in the fall or winter and completes its life cycle the following summer.

TOLERANT CROPS—Those crops which show no yield reduction from pesticide use.

This publication has been suggested and approved for use in the following states by these agricultural or cooperative extension specialists: Bert L. Bohmont, agricultural chemicals specialist, Colorado; Yukio Nakagawa, horticulturist and pesticides coordinator, Hawaii; Roland W. Portman, entomologist, Idaho; Harry G. Smith, pesticide specialist, Nevada; Alvin F. Gale, pesticide specialist, Wyoming.

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There are other environmental factors that may affect dermal exposure including wind, type of activity, application method, rate of application, and duration of exposure.

The skin affords protection for all other body organs. It also regulates body temperature, receives sensations, secretes, absorbs, and manufactures pigment. Any deviation of these functions from normal can affect skin health.

When using pesticides, all necessary precautions should be observed to protect the skin. (See Section IV, G. Protective Equipment.)

Oral Exposure

When a pesticide is taken into the mouth or orally in amounts sufficient to cause serious injury or death, it is consumed either by accident or by intent to do self-inflicted injury. Accidental oral ingestion, in most cases, is the result of removing the pesticide from the original labeled container and putting it in an unlabeled bottle or food container for storage in an area where children or irresponsible adults may consume it. Accidental splashing may be the cause of oral ingestion and in some instances pesticides may be transferred by wiping the face with the sleeve, cuff, or hand. Although oral ingestion is not considered a primary source of occupational exposure, pesticide absorption through the gastrointestinal tract is greater than through the skin.

Inhalation or Respiratory Route

Sometimes, pesticides are inhaled in sufficient quantities to cause serious damage to nose, throat, and lung tissues. The respiratory route is considered a great potential hazard for poisoning, as pesticides are nearly completely absorbed. Highly volatile pesticides, or those used in the form of gas for fumigation, dusts, aerosols, and fog, have the greatest potential of being inhaled. There are many protective devices available to reduce inhalation or respiratory exposure. (See Section IV, G. Protective Equipment.)

B. Need for Safety

Agriculture is faced with the need and the challenge of providing food, fiber, and forage for an ever-increasing population in the United States and abroad. There is also the need to provide protection of public health because of the increased population. These needs can be accomplished with the judicious use of pesticides as a management tool.

Through development and use of synthetic pesticidal compounds in the mid-forties, a management system in agriculture has emerged whereby man can deal with one of the most important limiting factors in production -- the direct loss of crops to pests. Widespread use of chemicals in farming is fairly new.

Consumers are benefited directly from the proper use of pesticides. They enjoy the world's most abundant food supply with variety and quality second to none. It is estimated that American consumers spend only 20% of their income on food and people in other countries spend 50% or more.

Increased mechanization, technology, and pesticides have made it possible for 8% of the population in the United States to produce enough agriculture commodities for the remaining 92% of the nation. The U. S. Department of Agriculture has estimated that without pesticide use an additional 120 million acres of land would have to be put into production in order to meet the requirements of present day food consumption.

Safe use of pesticides is everyone's responsibility. Pesticide safety prevents harm to persons and property. Pesticides are actually instruments of safety. By reducing insect-borne diseases, insecticides have saved over one million lives in the United States and over one hundred million lives in the world since the mid-forties. Pesticide use in hospitals, restaurants, and public buildings has prevented numerous illnesses. They protect our homes from termites and rats; our crops from insect and rodent destruction; our livestock from disease and insect pests; our plants from diseases; and our crops from being choked by weeds.

With proper application, pesticides rank among the safest farm aids used. They undergo exhaustive manufacturer's tests and pass stringent label requirements before being approved and registered for market by the Environmental Protection Agency. Pesticide residues and their effects are carefully monitored or surveyed. Teams of scientists maintain surveillances on soils, crops, water, air, animals, and mankind to insure that dangerous levels of pesticides are not accumulating in the environment.

Pesticides have an enormous safety margin when used properly. But, like automobiles, firearms, and medicines, they can be and sometimes are improperly used, causing accidents. Because of improper use, over 100 children and adults die of pesticide poisoning annually. Though these poisonings are fewer than deaths reported due to items such as aspirin, the number can be reduced.

There is no reason for pesticide misuse because there are many sources of information available for proper use. Manufacturers, Environmental Protection Agency, United States Department of Agriculture, Public Health Services, American Medical Association, and various state organizations all provide reliable sources of safety information.

Actually, a pesticide accident may begin the moment a person purchases a pesticide. The selection of type of pesticide, of formulation to be used, and even of the container type may be factors contributing to a pesticide accident.

Pesticide safety is an important topic to four primary groups of people: 1) the manufacturer, distributor, and dealer; 2) the applicator or user; 3) the customer (grower, farmer, fieldman); and 4) the public at large. Some of these people are dependent on the safe use of pesticides for their careers and livelihoods; some rely upon the proper use for economic control of plant diseases, insects, and weeds; and some are primarily concerned with overall safety and improvement of the environment. There can be no substitute for safety when it comes to pesticides. That is why safety deserves top consideration by aerial applicators, ground applicators, or any person using or applying a pesticide.

C. Selection of Pesticides

Primary consideration should be given to pesticide selection as it is the most important segment of carrying out an effective pest control program. Pesticide selection is instrumental in the effectiveness of the control obtained and its hazards to the applicator, other persons, animals, desirable plants, and wildlife.

Before making a selection, the pest problem should be identified by a competent person. Control measures should not be undertaken unless the pest problem is of economic importance, has the potential of developing into a problem, is of health importance, or is a nuisance.

After proper pest identification, select a pesticide with a specific use in mind. The pesticide should be one currently recommended by your county agricultural extension service and be registered for use by the EPA. Attempts never should be made to obtain double duty from a pesticide by, for example, using a crop insecticide in the home, unless both uses are specifically recommended. A highly concentrated pesticide used safely outside may be dangerous if used inside a building.

There are considerable differences in the safety of various pesticide formulations. Select the safest pesticide formulation whenever there is a choice. Granular type formulations are safer than sprays or dusts because they drift less. Formulations with greatest drift and dispersion potential are most likely to cause damage to desirable plants under unfavorable climatic conditions. These formulations can be of greater risk to the applicator if a toxic pesticide is being used.

Emulsifiable concentrate pesticides with a petroleum type carrier are generally more hazardous than water soluble ones because they penetrate the skin more rapidly and are difficult to wash off.

Estimate the amount of pesticide needed for a season and purchase just enough so it can be used to eliminate storage.

D. Mixing and Handling Pesticides

Pesticides by nature are poisonous materials and extreme caution should be used in mixing and handling them. They must be poisonous to kill or control the pest for which they are developed.

Though many pesticides have very low or no dermal toxicity, the concentrated form of many can be relatively poisonous through skin absorption. Protective gloves always should be used when handling the concentrated form of any pesticide. For very toxic materials, a respirator, protective clothing, and eye shields should be used to prevent inhalation or splashing the material on the skin or into the eyes. Many pesticides can burn or irritate the skin, even if not excessively toxic. If the proper clothing is worn, such as long sleeved shirts, this problem can be greatly reduced.

The first operation in mixing pesticides is to open and pour from the container. This should be done outdoors or in a well ventilated area. The plastic seal in the pouring spout, the bung, or any other type of outlet seal should be removed very carefully. Never position any portion of the body directly over the seal or the pouring spout. The release of pressure may cause the liquid to spew from the container. When pouring from a can with a spout, always keep the spout positioned at the top of the can to prevent an uneven flow of liquid, thus avoiding splashing.

If bags or sacks are opened carelessly by tearing rather than using a knife, dry formulations such as dusts and powders can billow up in large concentrations.

In mixing chemicals, all quantities of the active ingredient should be measured with extreme accuracy. Rates or dosages found on the label or recommended by the Agricultural Extension Service will do the job. Increasing the concentration may add to hazards and increase treatment costs. Containers to accurately measure ounces, pints, quarts, gallons, and scales should be kept in the area where pesticides are stored. There measures should be thoroughly cleaned after each use.

In some instances, it is possible for users to mix two pesticides together and make one application. Charts and information are available which indicate the compatability of different pesticides. Only those that are compatible should be mixed.

All pesticide containers should be treated as full, because those that appear empty may still contain enough of a highly toxic pesticide to cause poisoning until properly cleaned or disposed of.

When measuring, mixing, and handling, always stand upwind to avoid inhalation of pesticide dust and fumes. Use special containers -- drums or pails -- for mixing pesticides; never use food or beverage containers. Clean up spilled pesticides immediately. If the pesticide is accidently spilled on the skin, immediately wash it off with soap and water. Should the pesticide be spilled on clothing, change clothing as soon as possible and launder before wearing again. Do not store or wash contaminated clothing with other soiled clothing items.

Protective gloves should be washed before removing them; do not turn the gloves inside out when removing to prevent contamination of the insides. Replace protective gloves frequently regardless of signs of wear or contamination.

Persons mixing, handling, or applying pesticides should never smoke, eat, or drink until they have washed thoroughly. It can be a means of swallowing pesticides which have accumulated on lips.

E. Application of Pesticides

Prior to pesticide preparation and application the label should be read thoroughly even if the pesticide is familiar. Details are often forgotten and labels are frequently revised. Use protective equipment if prescribed no matter how uncomfortable it may be during hot weather. There is no choice -- the discomfort must be endured to use the pesticide safely.

There are several types of respirators available and the type to use will be clearly specified on the label. Specific respirators are approved for use with certain pesticides. Regular protective maintenance practices such as washing and replacing respirator cartridges should be observed.

Do not apply higher dosages or rates than specified on the label or recommended by the Agricultural Extension Service. To apply correct pesticide amounts, application equipment (sprayer, duster, spreader, or injector) must be calibrated or the output determined. Knowledge of equipment output is essential to compute the amount of pesticide needed in the mixture to treat a given area.

Be sure the sprayer or applicator is clean, in good condition, and operating properly. Poorly operating equipment can cause unnecessary hazard to the user as well as possible damage to the crop. Extra time spent during spraying to fix and adjust equipment that is in poor operating condition can cause excessive exposure to the pesticide. Do not blow out clogged hoses, nozzles, or lines with your mouth. Use the proper type of equipment; as an example, never attempt to use a powder that is intended to be applied with water in a dust applicator.

The application should be at the proper time using recommended dosages to prevent illegal residues from remaining in or on food, feed, or forage crops. On many pesticide labels there are a number of days interval prescribed between the last pesticide application and harvest. These waiting intervals should be followed closely. For livestock there is a waiting period between treatment and slaughter.

Precautions should be observed to guard against drift of pesticides onto nearby crops, pastures, or livestock. Extreme care should be observed to prevent application from contaminating streams, ponds, lakes, or wells. If pesticides must be applied when there is a breeze, drive or spray into, or at right angles to, the breeze. Then the pesticide will not blow into the applicator's face.

Be careful not to rub eyes or mouth with your hands during application of the pesticide. Some pesticides are readily adsorbed by the mucous membranes of the eyes, nose, and mouth. An amount that would not cause problems on the skin can be serious on these membranes.

Leather and cloth shoes cannot be cleansed of pesticides; therefore, rubber shoes should be used during application. Pesticide contamination of leather and cloth shoes can aggravate skin problems such as athlete's foot.

If a person feels ill or notices any irregular bodily symptoms when applying pesticides, work should cease and efforts should be made to seek medical attention.

F. Pesticide Formulations

There are many types of pesticide formulations. The most commonly available are emulsifiable concentrates, wettable powders, dusts, granules, aerosols, and fumigants.

Emulsifiable concentrates (E.C.): A liquid formulation which has the active ingredient dissolved in one or more water-insoluble solvents. Emulsifiers are generally added to insure mixing with oil or water. E. C.'s usually contain 10-80% (1-8 lb. per gallon) of active ingredient. They readily remain in suspension due to the emulsifiers and are easy to handle. Care must be taken when using toxic pesticides in this form because many of them are readily absorbed by the skin. Emulsifiable concentrates sometimes pose chemical compatability and phytotoxicity problems; however, this can sometimes be overcome by using the wettable powder form.

Wettable powders (WP): The powder form of a pesticide that is diluted with water to form a suspension. Powder particles are kept from floating by addition of a wetting agent and the material is kept in suspension by use of a dispersion agent. Wettable powders generally contain 15-75% active ingredient. WP.'s with the higher percentage of active ingredient are generally more desirable to use because they result in less noticeable residue and cost per unit of active ingredient is less. Agitation to keep wettable powders in suspension in the spray tank is generally needed when applications are made. Wettable powder formulations are one of the safest to use when phytotoxicity or compatability might be a problem. Sometimes hard or alkaline water may cause difficulty when mixing wettable powders.

Dusts: Mixtures of one or more pesticides in a finely ground diluent such as talc. Dusts are easier to handle from the standpoint of preparation than either emulsifiable concentrates or wettable powders. They are generally ready-to-use as purchased. They generally are available as 1-10% active ingredient. The potential danger of drift is greater with dusts and many are more irritating to the applicator than sprays. If dusts are applied to dry surfaces poor results may be obtained. Early morning or late evening application is desirable when dew is present to achieve desired results.

Granules: Pesticide formulations impregnated upon a carrier the size of sand grains or larger. Carriers are most often inert materials such as ground corn cobs. They are generally available as containing 1-10% active ingredient. This formulation has very little drift potential and from this standpoint has a great advantage over other type formulations. Granules are easy to handle and are desirable for homeowners to use as long as spreaders are first calibrated for the material being used. Granules are generally more expensive per unit of active ingredient; however, the low cost for application and variety of uses are responsible for their increase in popularity.

Aerosols: Pesticide particles are dispersed in a gas propellant. When used, liquid particles are dispensed as a fog. Liquid gas aerosols contain the pesticide dissolved in a low boiling point liquid such as dichlorodifluoromethane, methyl chloride, and others held under pressure in a metal cylinder. As the valve is opened, a fine spray is ejected, the propellant is quickly vaporized, and the pesticide remains suspended in the air. Aerosol sprays are a convenience item which are popular and easy to use; however, they are expensive on a unit of active ingredient basis.

Fumigants: Gas, liquid, or solid formulations produce a gas, vapor, fume, or smoke. Their uses are limited to closed structures, greenhouses, and soil. They contain a pesticide or mixture of pesticides, a diluent, and generally a material having a characteristic odor to serve as a warning. They are one of the most hazardous formulations to use and extreme caution should be taken when they are used. For this reason, they are not generally recommended for homeowner use.

Miscellaneious formulations: There are several other formulations of pesticides available but less commonly used. These formulations are: water soluble powders and concentrates; oil soluble concentrates; pastes; oils; invert emulsions; prepared baits; bait concentrates; and a relatively new flowable powder formulation. Water soluble powders and concentrates form true solutions, not suspensions, when added to water. Oil soluble concentrates are similar to emulsifiable concentrates except they will not mix with water but are generally diluted with fuel oil, diesel oil, or kerosene. Pastes are like wettable powders except in the slurry form. Oils are low cost, spread easily over a surface, and are relatively easy to mix and handle.

Invert emulsions are water in oil mixtures in which each water droplet is surrounded by oil. Some difficulty has been encountered in applying invert emulsions due to high viscosity. Their apparent advantage is to reduce drift potential in low volume and aerial applications. Bait concentrates may be solids and liquids which are diluted with food or liquids before use. The flowable powder formulation is a wettable powder suspension in a liquid mix. The advantage of it over conventional wettable powders is the ease in which it can be mixed into water to form a suspension.

In most cases, it is most economical to purchase pesticides with the highest percentage of active ingredient and dilute to the desired concentration. On an unit of active ingredient basis there is less filler or carrier, and shipping costs are lower on higher percentage concentrated pesticides. In some instances, pesticides may be available in several different forumlations.

G. Protective Equipment

The use of protective equipment is becoming increasingly more important when using pesticides. The present trend in some areas of pest control, primarily insect control, is to utilize more compounds that are more acutely toxic to man but less persistent in the environment.

Protective clothing and other safety devices do provide some protection against skin contact and inhalation of toxic pesticides by the user; however, their use does not eliminate the necessity to follow other essential precautions.

The type and amount of protective clothing and equipment needed depends upon the job being done and the type of pesticide being used. Several factors are pertinent for the operator to consider when determining protective equipment needs:

1) The toxicity, concentration, and vapor action of the pesticide being used.
2) The degree of exposure.
3) The length of exposure.
4) The extent to which the pesticide can be absorbed through the skin.

These requirements vary in a number of situations. Some examples are: 1) A person applying a toxic material in a closed area (greenhouse or tank) is greatly exposed. Complete protective covering should be used consisting of a hood, coveralls, rubber gloves, and rubber boots. The respirator should be a full-face gas mask equipped with a canister and fume type filter. 2) An applicator treating an orchard or trees should wear a rain hat or hood, raincoat, rubber gloves, and rubber boots. A chemical-cartridge respirator or a gas mask can be used. 3) An applicator spraying or dusting a crop field or livestock with a toxic pesticide should wear a hat, coveralls, rubber gloves, and rubber boots. The respirator can be of the chemical-cartridge type.

Coveralls or Waterproof Rainsuits

Skin contamination can be reduced by wearing coveralls that afford the entire body protection. If the situation is such that coveralls would be wet through with mist, spray, or spillage, a waterproof rainsuit should be used. Coveralls and rainsuits should be thoroughly washed with soap and water after each use. Contaminated protective equipment should be handled as carefully as the pesticide itself. Rain gear should be periodically checked for cracks and holes.

Head and Neck Coverings

Efforts should be made to protect the hair, skin about the head, and neck from pesticides. Headgear would include one of the following: waterproof rainhat, safety hard hats, or caps. Waterproof or repellent parkas offer good protection for the head and neck at the same time. Old felt hats or other types of absorbent headgear should not be worn as they adsorb pesticides, especially in the area of the sweatband. Once contaminated they can provide a source of continuous and very dangerous skin contact. Research has indicated that the head-neck area is a body area of greater pesticide absorption than the hands or arms.

Gloves

In general, natural rubber gloves should be used when handling organophosphorus, carbamate, and other pesticides that are readily absorbed through the skin. There is one exception, however, some fumigant type pesticides cause rubber gloves to disinergrate and polyethlene gloves must be used. The type of glove to use is usually suggested by the pesticide manufacturer. There are lightweight unlined gloves available with long enough gauntlets to protect the wrist area but flexible enough to allow freedom of finger movement. Several types of disposable gloves are presently being manufactured that can be used when applying certain types of pesticides. Gloves should be checked very carefully at regular intervals for small holes. This can be accomplished very easily by filling the gloves with water and squeezing; discard the gloves if water is emitted.

Leather and cotton gloves are very undesirable when handling or applying pesticides and never should be used. They can absorb the material and become a constant source of pesticide exposure. The wrong selection of gloves and those with holes present more potential hazard to poisoning than if no gloves are worn.

The hands are generally more exposed as the result of contact with the concentrated form of pesticides during measuring, mixing, and loading. Cuts and abrasions allow a more direct route of the pesticide into the body and should be very carefully protected.

Rubberized Boots

Again as with gloves, leather and canvas shoes can absorb the pesticide and hold it in contact with the wearer, making this type of footwear undesirable when applying pesticides. Only rubberized boots should be worn when handling or spraying pesticides on a large scale. Handling them very carefully, contaminated boots should be washed with soap and water, inside and out, and dried thoroughly.

Waterproof boots or footgear should be worn during most any type of pesticide application. Foot protection is important when hand applications of pesticides are made.

Goggles

Protective shields or goggles should be used especially when there is any chance of a pesticide coming into contact with the eyes. Eye protection is most often needed when measuring or mixing pesticide concentrates as well as when spray or dust drift might be a problem. Goggles or eye shields should be kept clean at all times.

Respiratory Devices

Some means of protection for the respiratory route is needed when toxic dusts and vapors or small spray droplets are prevalent. It has been found that pesticide exposure is usually relatively low when dilute sprays are being applied with conventional application equipment which is probably due to the larger droplet sizes produced. When low volume equipment is being used, respiratory exposure is increased by the smaller droplets or particles being produced.

When applying toxic pesticides, a respiratory device is one of the most important pieces of protective equipment both for commercial and private pesticide applicators.

There are primarily two types of respiratory devices being used when handling toxic pesticides -- the chemical cartridge respirator and the gas mask.

Respiratory protection for most types of pesticide application out-of-doors can be provided using cartridge-type respirators. These respirators usually contain an absorbent material such as activated charcoal in a replaceable cartridge. All of the respirators discussed in the following latest USDA report (February 1966), page I-22, also have efficient filters that remove dust and spray particles.

The cartridge-type respirators are generally designed to cover the mouth and nose, offering no eye protection. They may have one or two cartridges.

Gas mask type respirators generally cover the entire face area. A canister may be directly attached to the mask or attached by a flexible rubber hose. The canister filters used in gas mask type respirators generally contain more absorbent material and longer-life filters than those used in respiratory cartridges.

The life of chemical absorbing cartridges or canisters may vary according to the pesticide concentration encountered; and also are affected by humidity, temperature, and volume of breathing.

When fumigating or applying highly toxic pesticides in confined spaces, it is advisable to use a supplied-air type respirator. These have a special compressed air supply tank attached with a breathing hose to a hood worn by the operator.

There are several precautionary practices to follow when using respirators:

1) Filters should be changed twice a day or oftener if breathing becomes difficult.

2) Cartridges should be changed with each 8 hours of use or if pesticide odors are detected.

3) Filters and cartridges should be removed after each use and the facepiece washed with soap and warm water, rinsed, and dried thoroughly. Facepieces should be placed in a well ventilated area to dry. Safety precautions should be used when washing a contaminated respirator.

4) Respirators, filters, and cartridges should be placed in a plastic bag and stored in a clean, dry place.

RESPIRATORY DEVICES FOR PROTECTION AGAINST CERTAIN PESTICIDES[1]

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BACKGROUND

When the organophosphorus compounds were found highly effective in controlling insects in greenhouses and on agricultural crops, efficient respiratory protective devices became a necessity for persons handling these insecticides. In the absence of any source of information on the adequacy of the devices then available, the former U.S. Bureau of Entomology and Plant Quarantine undertook an investigation, primarily to ensure the protection of its research personnel. Although the data obtained were necessarily limited in scope, the test results were published because of their safety value to the public. On June 22, 1949, the Bureau issued a statement on minimum safeguards to be observed in filling greenhouse aerosols containing parathion, other organophosphorus chemicals, and methyl chloride produced under license agreements issued under U.S. Patent 2,321,023 (a public-service patent assigned to the Secretary of Agriculture). In this statement were mentioned three commercially available gas-mask canisters that had been found to give adequate protection against these chemicals. Also included were other precautionary measures to be observed.

Subsequently, lists of respirators and gas-mask canisters found to give adequate protection against other pesticides were issued by the Bureau on May 4, 1950, August 24, 1951, and May 1, 1952; and by the Agricultural Research Service on July 12, 1954 (revised August 9, 1954), June 27, 1955, April 29, 1957, July 22, 1957, March 20, 1961, September 1962, April 1963, and June 1964. This publication contains all information available as of October 31, 1965, and supersedes all previous releases and publications on this subject by the Department.

In November 1951, Fulton and coworkers in the Bureau (1)[2] described test methods for determining the protective efficiency of respirator cartridges and gas-mask canisters. In August 1955, Fulton and others (4)reported on testing methods used and respiratory protective devices for insecticides in agricultural use. In January 1957, Fulton and McClellan (2) reported on respirators and gas-mask canisters found effective against several representative fungicides and nematocides. In August and September 1958, Fulton and Smith (3) described in detail the methods used in testing respiratory devices against pesticides, and they tabulated all the information obtained up to that time. Until recently the methods usually consisted of drawing pesticide-laden air through the cartridge or canister into a chamber containing aphids or spider mites of known age on plants. By observing the mortality 4 to 6 hours after removal from the chamber, the effectiveness of the device under test in removing the pesticide from the air stream may be determined. Beginning in 1965 the respirators for organophosphorus pesticides have been tested by using gas-liquid chromatographic columns equipped with ionizing detectors to check samples of air drawn through filter cartridges or canisters. The air before purification contained finely atomized aerosols of water emulsions of one of two representatives of this group of pesticides, mevinphos or dichlorvos, dispersed at the rate of 50 mg. of pesticide in a cubic meter of air as described by Yeomans (6). For fungicides, the air after passage through the cartridge or canister was analyzed by methods cited by Fulton and McClellan (2).

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[1] Mention of a device or a proprietary product in this publication does not constitute a guarantee or warranty by the U.S. Department of Agriculture and does not imply approval by the Department to the exclusion of other products that may also be suitable. No discrimination is intended against any company not mentioned nor is any guarantee implied for the products of the companies listed. The information in this publication shall not be used in sales promotion or in advertising which expresses or implies endorsement of any product by the Department. February, 1966.

[2] Underscored numbers in parentheses refer to Literature Cited.

TYPES OF RESPIRATORY DEVICES

Two kinds of respiratory protective devices are in general use--chemical cartridge respirators (hereinafter referred to as respirators) and gas masks. Most respirators are designed as half-face masks that cover the nose and mouth but do not protect the eyes (fig. 1). They have one or two cartridges attached to the facepiece by a clamp or secured in a holder. The respirator facepieces are equipped with one-way valves which allow the inhaled air to pass through the cartridges but prevent the exhaled moist breath from passing through the cartridges. Gas masks usually cover the entire face (fig. 2). Their facepieces are made to hold a canister directly or to connect to the canister with a flexible hose. The hose-type canister is carried on the chest or back by means of straps.

Respirator cartridges usually contain an absorbing material such as activated charcoal. All the respirators listed in this report also have efficient filters, which remove dust and spray particles and thus prolong the life of the absorbing material. Gas-mask canisters always contain more absorbing material and filters with longer life than the respirator cartridges. The volume of chemical-absorbing cartridges and gas-mask canisters ranges from 50 to 100 ml. (usually the latter) for cartridges, 180 to 500 ml. for chin-style canisters, and 750 to 1,800 ml. for chest-type canisters. Cartridges and chin-style canisters have a shorter useful life than regular canisters because of the smaller volume of absorbing material in them.

The life of chemical-absorbing cartridges or canisters will be affected by humidity, temperature, and volume of breathing. High humidity shortens the life of cartridges and canisters in use and in storage. Mist, sprays of water, and rain reduce the effective period of the units. Cartridges and canisters in storage will gradually lose their effectiveness because of the exchange of air within the unit due to change in temperature and atmospheric pressure.

A supplied-air respirator (fig. 3) has a combination blower-filter with a breathing hose leading to a hood worn by the operator. It incorporates both a safety helmet and a faceshield. The unit supplies purified air, which has

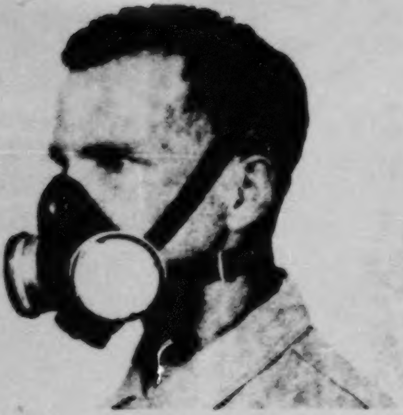

Figure 1.--Commercially available respirator adequate for protection against pesticides under certain conditions, showing proper adjustment of straps.

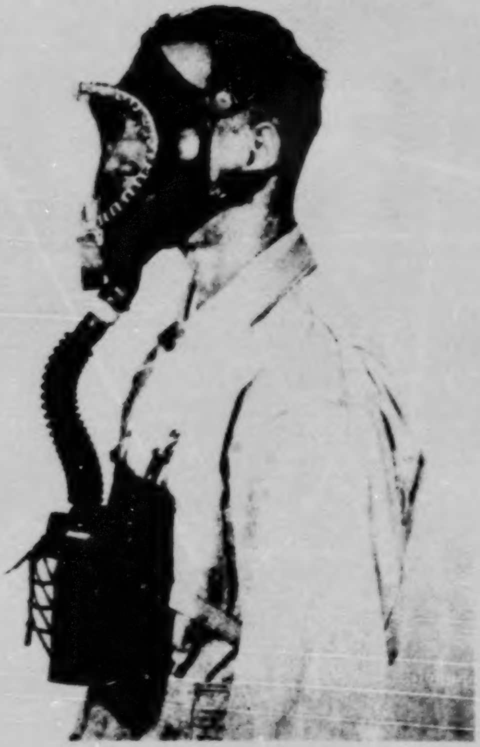

Figure 2.--Gas mask, showing proper adjustment of facepiece.

passed through filters and a charcoal adsorbing unit for removing dust or spray particles and insecticide vapors. Units for mounting on tractors or on equipment for application of pesticides are obtainable for operation on 6- to 24-volt direct or 115-volt alternating current.

USE OF RESPIRATORS AND GAS MASKS

Instructions given on pesticide labels concerning respiratory protection should be carefully followed. When the use of respirators or gas masks is called for to protect against dusts and mists, any of those listed in this publication can be employed for the pesticides listed in the tabulation on pages and

Because of the different in their protective capacity, gas masks, not respirators, must be worn when pesticides are formulated in close or inadequately ventilated spaces. We recommend that gas masks be worn in greenhouses (fig. 4), and in buildings when highly toxic materials are applied. For special operations, such as dusting or spraying under tobacco shade cloth or in citrus groves on hot, calm days, a full facepiece with a chin-style gas-mask canister is available. It is necessary that respirators be used in handling pesticides during the loading of distribution equipment (fig. 5),

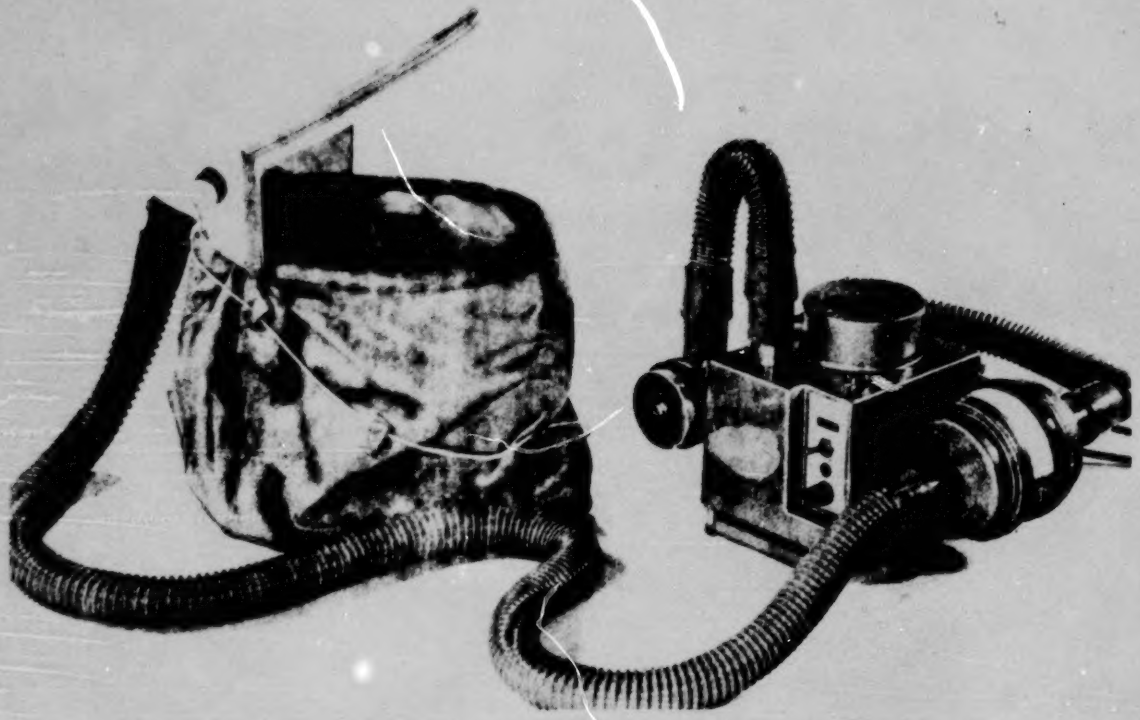

Figure 3.--Supplied-air respirator with blower-filter and hood.

when containers are being disposed of, and whenever operators are exposed to obvious amounts of dusts or mists of the more dangerous pesticides. Field operators who may be exposed continuously during the day or for successive days to small amounts of toxic pesticides--even those not readily detectable--should faithfully use respirators as a precaution.

Respirators will give adequate protection to airplane pilots against most insecticides during normal dusting or spraying operations, but care should be taken to select and wear goggles that provide a tight seal with the respirator around the nosepiece. Pilots who are exposed to high concentrations of the more toxic pesticides must wear gas masks.

When respirators are used, the following practices are necessary: (1) Change filters twice a day or oftener if breathing becomes difficult. (2) Change cartridges after 8 hours of actual use or oftener if any odor of the pesticides is detected. (3) Remove filters and cartridges and wash the facepiece with soap and water after use. After washing, rinse the facepiece to remove all traces of soap. Dry it with a clean cloth that is not contaminated with the pesticide. Place the facepiece in a well-ventilated area to dry. (4) Store the respirator, filters, and cartridges in a clean, dry place--preferably in a tightly closed paper or plastic bag.

The respirator should be fitted properly on the face, not too high on the

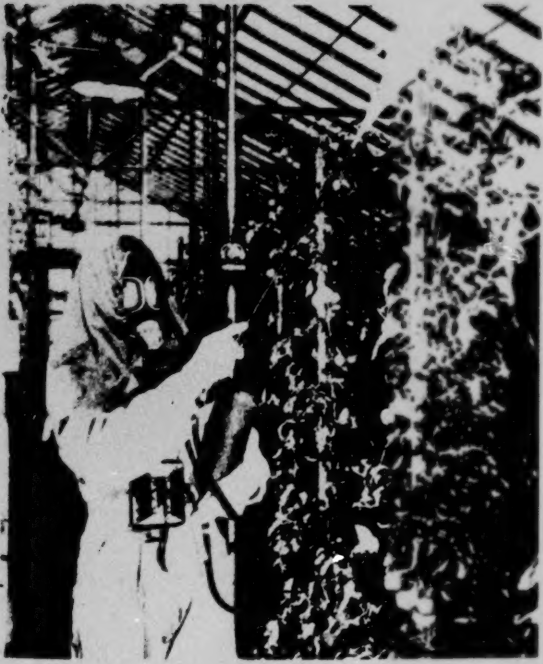

Figure 4.--Gas mask and protective clothing used during aerosol treatment in greenhouse.

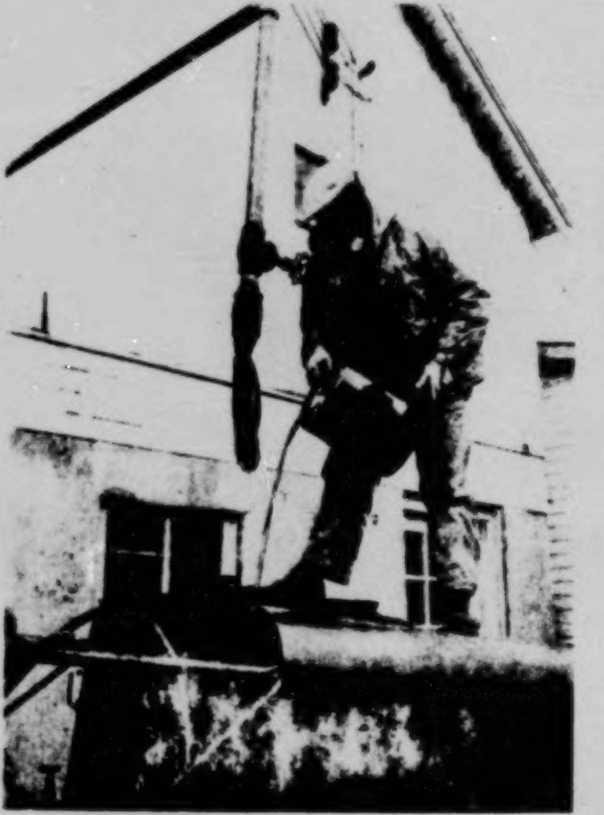

Figure 5.--Wearing respirator while loading spraying equipment with insecticide concentrate.

nose, with the narrow part over the bridge of the nose, and the chincup contacting the underside of the chin. Adjust headbands just tight enough to insure a good seal (figs. 1 and 2). Manufacturers can supply a special facepiece if the standard one does not fit.

We have not tested the respiratory devices listed on pages against fumigants. For fumigating the holds of ship and grain elevators, where oxygen may be insufficient, a hose mask with a blower or a self-contained air-supply unit must be used. The hose mask is connected to an air source free of the toxic material. Demand-type masks connected to a compressed-air cylinder also can be used for short periods. These cylinders are available in various sizes--the most common size contains 22 cubic feet of air, enough for 15 to 20 minutes of service. When heavy work is involved, some authorities do not favor the use of an oxygen mask because when the operator first puts on this type of mask, his lungs require a certain period of time to adjust so he can breathe normally.

When applying grain fumigants, the operator should follow closely the recommendations of the fumigant manufacturer. In some situations, as when pouring concentrated fumigating material directly on the surface of grains, very high concentrations of gas may be close to the air inlet of the gas-mask canister. The operator may reduce the concentration of the gas in the intake air by mounting the canister on his back.

The use of a respiratory protective device does not eliminate the need for other precautions in handling toxic pesticides. Provide for adequate ventilation of the area where pesticides are loaded or mixed. Always wear well-made natural-rubber latex gloves when handling concentrated materials. Check the condition of the gloves frequently and discard them if they develop pinholes or breaks. For an understanding of the general precautions that must be taken if insecticides are to be used safely, consult the "Suggested Guide for the Use of Insecticides to Control Insects Affecting Crops, Livestock, and Households, 1965" (5).

If an operator shows any sign of dizziness or nausea, he should be removed immediately from the area and placed in the care of a physician before he return to work.

The commercially available respirators and gas-mask canisters listed below have been tested and found to give adequate protection against dusts, mists, and low vapor concentrations of the pesticides listed on pages The equipment was tested in the presence of 50 mg. of pesticide per cubic meter both for gas-mask canisters and respirator filter-cartridges by a method described by Yeomans (6). Because of leakage around the facepiece, half-mask respirators should not be worn when concentrations of pesticides are greater than 5 mg. per cubic meter. We have not tested the canisters against commercial fumigants (high vapor concentrations) because this function was assumed by the U.S. Bureau of Mines.

All tests were conducted with samples of respirator filter-cartridges and gas-mask canisters furnished by the manufacturers. There may be other suitable products available, samples of which we did not receive for testing.

3/ The authors acknowledge the assistance of Earl Fields, Entomology Research Division, in carrying out this testing.

List of Respirators and Gas-Mask Canisters[4]

Respirators with Face-Mounted Cartridges

J. C-241 Respirators, with CMP cartridge and C-241-7 filter. (Pulmosan Equipment Corp.)
L. Respirator No. 6058, equipped with combination filter-cartridge R-58. (American Optical Co., Safety Division) (Also sold by Sears, Roebuck & Co. as Cat. No. 9K1857, cartridge No. 9K18575)
O. Agritox Respirator, equipped with cartridge 11P and filter R553. (Willson Products Division, The Electric Storage Battery Co.)
P. Protex Respirator, equipped with 7500-21 cartridge and 7500-23 filter. (Welsh Manufacturing Co.)
R. Farm Spray Respirator (Improved) No. 93938, equipped with No. 93939 GMP combination filter-cartridge. (Mine Safety Appliances Co.)

Supplied-Air Respirators

a. Whitecap System model 250, including No. 4002 helmet assembly with rubberized shroud, No. 1801 cartridge, No. 1603 filter element, and No. 1731 extra fine filter element. (Rite Hardware Manufacturing Co.)

Gas-Mask Canisters

1. Chin Style (282-OVAG-R) Insecticide Canister. (Acme Protection Equipment Co.)*
3. Canister G3FD. (Willson Products Division, The Electric Storage Battery Co.)
4. Universal-type canister, Type N, bearing Bureau of Mines approval for toxic smokes.*
    BM-1436 (Acme Protection Equipment Co.)
    BM-14F-66 (Mine Safety Appliances Co.)
    BM-1445 (Willson Products Division, The Electric Storage Battery Co.)
    BM-1448 (Davis Emergency Equipment Co.)
5. Canister No. 084 OVAG-R (Large size). (Acme Protection Equipment Co.)*
6. Canister No. MH3FC, Chin Style. (Willson Products Division, The Electric Storage Battery Co.)*
7. Canister No. 3229 Type C-4. (Davis Emergency Equipment Co.)
9. Canister GMP, Chin Stule, Cat. No. 88180. (Mine Safety Appliances Co.)*
10. Canister GMP, Cat. No. 88181 Industrial size. (Mine Safety Appliances Co.)*

* These canisters are equipped with smoke filters. Do not use other canisters for smokes.

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[4] The letter and number designations of items as listed in ARS 33-76 issued in September 1962, Supplement No. 1 issued in April 1963, and ARS-33-76-1 issued in June 1964, have been retained to avoid confusion. Letters and numbers of devices that do not protect against the full range of pesticides have been omitted in the present list.

The addresses of the companies supplying these respirators and gas masks are given below. Respirators are also available from pesticide distributors and mail-order houses.

Acme Protection Equipment Co., 1201 Kalamazoo St., South Haven, MI 49090.
American Optical Co., Safety Division, Southbridge, MA 01551.
Davis Emergency Equipment Co., 45-57 Halleck St., Newark, NJ 07104.
Mine Safety Appliances Co., 201 North Braddock Ave., Pittsburgh, PA 15208
Pulmosan Safety Equipment Corp., 644 Pacific St., Brooklyn, NY 11217.
Rite Hardware Manufacturing Co., 540 West Chevy Chase Drive, Glandale, CA 91209.
Welsh Manufacturing Co., 9 Magnolia St., P.O. Box 800, Providence, RI 02909.
Willson Products Division, The Electric Storage Battery Co., Reading, PA 19603.

Respirators and gas-mask canisters listed above will protect against dusts, mists, and low vapor concentrations of the following pesticides:

List of Pesticides or Pesticide Mixtures

aldrin
azinphosethyl
azinphosmethyl
Bayer® 39007 (*o*-isopropoxyphenylmethylcarbamate)
Bidrin® (3-hydroxy-*N*,*N*-dimethyl-*cis*-crotonamide dimethyl phosphate)
calcium copper chloride
carbaryl (Sevin)
carbophenothion (Trithion)
Ceresan® M [(*N*-(ethylmercuri)-*p*-toluenesulfonanilide]
chlordane
Ciodrin® (*alpha*-methylbenzyl 3-hydroxycrotonate dimethyl phosphate)
D-D ® (dichloropropane-dichloropropene mixture)
DDT
demeton
diazinon
dicapthon
dichlorvox (DDVP)
dieldrin
dimethoate
diozathion (Delnav)
disulfoton
endosulfan (Thiodan)
endrin
EPN
ethion
ethylene dibromide
ferbam
isobenzan
Kepone ® (decachlorooctahydro-1,3,4-metheno-2*H*-cyclobuta [*cd*]pentalen-2-one)
lindane
malathion
methyl parathion
Methyl Trithion ® [*S*-(*p*-chlorophenylthio)methyl *O*,*O*-dimethyl phosphorodithioate]

List of Pesticides or Pesticide Mixtures (continued)

mevinphos (Phosdrin)
naled emulsion (Dibrom)
naled xylene solution (Dibrom)
nicotine
Panogen ® [cyano(methylmercuri)guanidine]
parathion
phorate
phosphamidon
Phostex ® [a mixture of bis(dialkyloxyphosphinothioyl) disulfides (alkyl ratio 75% ethyl, 25% isopropyl)]
ronnel
schradan
Shell Compound 4072 [2-chloro-1-(2,4-dichlorophenyl)vinyl diethyl phosphate]
tepp
Terrachlor ® (pentachloronitrobenzene)
Vapam ® (sodium N-methyldithiocarbamate)
Zectran ® (4-dimethylamino-3,5-xylyl methyl carbamate)
zineb
Zinophos (O,O-diethyl O-2-pyrazinyl phosphorothioate)
azinphosmethyl plus azinphosethyl
carbophenothion plus methyl parathion plus DDT
dichlorvos plus malathion
methyl parathion plus endrin
Methyl Trithion ® plus DDT
toxaphene plus DDT plus methyl parathion plus ethion

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(2) ____________ and McClellan, W. D.
1957. Respiratory protective devices for agricultural pesticides. Phytopathology 47: 56-57.

(3) ____________ and Smith, F. F.
1958. Respiratory protective devices. Methods for testing them against pesticides. Agr. Chem. 13 (8): 30-32; 13 (9): 22-24.

(4) ____________ Smith, F. F., and Gelardo, R. P.
1955. Respiratory protective devices for agricultural use. J. Econ. Entomol. 48: 457-459.

(5) U. S. Department of Agriculture.
1965. Suggested guide for the use of insecticides to control insects affecting crops, livestock, and households, 1965. U. S. Dept. Agr., Agr. Handbook 290 (rev. May 1965), 200 pp.

(6) Yeomans, A. H.
1965. Inhalation hazard. Agr. Chem. 20 (11): 56,57,61.

H. Aerial Application Safety

Though a great deal of time is spent providing general pesticide safety information common to all types of pesticide use, the trend of more pesticides being aerially applied each year creates a need for additional safety information devoted to this area of specialization. Aerial application of pesticides has developed into an extensive, skilled profession. Various hazards are associated with the work, and these can be minimized by observing safety precautions.

Equipment

The aircraft is the most important item to consider. The type of aircraft selected should be dependent upon the work it will be used for. For treating large areas with long runs, fixed-wing aircraft are generally used more than other types. Helicopters or rotary wing aircraft are generally safer and more maneuverable for treating small areas, particularly those which have obstacles.

Aircraft should be designed specifically for aerial application to protect pilots and increase operating efficiency. Aerial application aircraft are equipped with numerous safety features not found in conventional types. These features include: 1) Ease of control during slow flight and partial aileron control during stalls; 2) Special ventilation that reduces pilot exposure to pesticides; 3) Provisions for pilot comfort to keep fatigue at a minimum; and 4) Good visibility in all directions.

Fixed-wing aircraft that have boom-and-nozzle equipment should not have booms that are longer than three-fourths of the wingspan. Longer booms which extend near the wing tips will result in spray being picked up by the wingtip vortices causing uneven spray patterns and in some cases increasing drift potential.

Aircraft should be equipped with a positive cutoff valve to prevent leaking when the spray is shut off at the end of swath runs. Some valves are equipped with a vacuum feature reducing the risk of dribbling nozzles.

Ground Crew

Members of ground crews including mixer, loader, and flagman should have access to protective equipment. (See Section IV, G. Protective Equipment). In addition to protective equipment, ground crew members should have immediate access to an adequate supply of soap and water.

The option to wear and the type of protective equipment needed will be dictated by the toxicity of the pesticide being used. Full protective equipment should be worn and all safety precautions observed when ground crews are working with materials as toxic as parathion.

Ground crew personnel should bathe and change clothes each day or immediately if a concentrate or toxic pesticide is accidently spilled on their clothing or skin.

It is important that ground crews be able to recognize symptoms of pesticide poisoning. Many times, poison symptoms are more obvious to others than the victim himself. Any abnormal reaction may indicate the onset of pesticide poisoning.

When water is drawn from streams or ponds for pesticide application purposes, be sure that no pesticide flows back into the water source.

Accidently spilled pesticides should immediately be cleaned up by ground crews to protect persons and animals from coming into contact with them. Pesticide spills are usually washed thoroughly on hard surfaces and covered with soil when spills are on bare ground.

Pilot Safety

The greatest amount of responsibility in conducting a safe aerial application program is the burden of the pilot. The pilot must be aware of any particular condition that may affect him personally as well as drift and other hazards that could be detrimental to humans, livestock, crops, wildlife, and any other environmental situation.

With proper precautions, the applicator pilot should experience less actual exposure to pesticides than the ground crew. For his safety there are several points to consider.

1) The pilot should not assist the ground crew when toxic pesticides are being mixed or loaded. He should remain on the windward side of the loading operation to avoid inhalation or exposure to toxic materials.

2) He should anticipate greater than normal hazard when applying a very toxic or highly concentrated pesticide.

3) The pilot should anticipate increased potential of hazards when fatigue results from flying for long periods.

4) The pilot should never turn or fly through the drift of the previous swath.

5) He should be constantly alert to detect pesticide leaks or accidental spillage inside of the aircraft. The airplane cockpit should be tight to prevent pesticide spray or dust particles entering during application. Cockpits should be cleaned frequently.

6) A safety helmet and shoulder harness should always be worn during flight.

7) When applying toxic pesticides, the proper type of protective equipment should be used.

8) It is of utmost importance that the pilot is able to recognize symptoms of pesticide poisoning such as dizziness, blurred vision, watering of the eyes, or nausea. Flying should cease if any of these symptoms are evident.

9) Clothing worn during application should be laundered each day.

Drift Control

Complete elimination of drift during aerial application is nearly impossible, but there are several factors to consider that help to keep it at a minimum.

Of utmost importance is wind velocity; when there are excessive winds, pesticides cannot be applied without drift. The application operation should cease immediately when wind velocity creates a drift hazard.

When possible, use sprays rather than dust applications if there is a choice. Granular materials are even less likely to drift than sprays or dusts; however, fewer pesticides are available as granulars, and sometimes application costs are greater.

Fine spray droplets will drift easier and farther than coarse spray droplets. Pesticides applied in oil will tend to drift farther than those applied in water.

The extent of drift can be reduced by keeping the altitude of flight as low as possible. Precaution should be observed to maintain effective pesticide dispersal and to consider the safety of the operation.

Dispersal equipment should be calibrated precisely to produce the desired rate of application. Consideration should be given to height of flight and swath coverage. Sometimes, under some conditions, temperature variations between air and ground will cause inversions which will prevent the pesticide application from settling to ground. If this occurs, pesticide application should be postponed immediately.

When aerial pesticide applications are made over rough terrain, the downhill movement of surface air can carry spray a considerable distance outside of the target area. The pilot should make allowances for this air movement. Aerial applications should not be attempted on very small fields where hazards of drift to adjoining fields is unavoidable.

Treatment of fields near canals, streams, lakes, or ponds should be made with extreme caution. The swaths should be parallel to the water so that turns will not be made across it.

Pilots should not prime the application equipment or test the flow rate while ferrying between the airstrip and the area to be treated.

It is the pilot's responsibility to see that the aircraft and its equipment is cleaned daily or after each use to prevent pesticide spray from building up.

Management and Supervision Safety

The overall sole responsibility of a safe pesticide application operation belongs to the managers or owners of the business. They should have all safety devices needed in the aircraft to protect the pilots. Aircraft dispersal equipment should be in good working order, delivering the desired rate and swath patterns. Loading equipment should be up-to-date to provide efficiency and safety for the ground crew operation. Pilots and workers exposed to organophosphate pesticides at regular intervals should be required to take blood cholinesterase tests frequently.

Immediate supervisors should be sure all workers understand the nature of the pesticide being used and what to do if poisoning occurs. The names of physicians and hospital to contact should be immediately obtainable if an emergency arises. All workers including the pilot should be required to wear protective equipment when needed. At least two men should work together when toxic pesticides are being used. It is the supervisor's responsibility to clear the area being treated, and if the material is toxic to bees, notify beekeepers.

I. Toxicity of Pesticides

The toxicity values of a pesticide is at the best just a relative measure to estimate its toxic effects on humans or other animals. One must keep in mind, when thinking of toxicity of pesticides, that any chemical substance is poisonous or toxic if absorbed in an excessive amount; therefore, the poisonous effect of a chemical is dependent on the amount consumed or absorbed. If enough common salt (sodium chloride) is consumed at one time it is quite poisonous.

The assumption can be made, therefore, that all pesticides in sufficient amounts can be toxic or poisonous. They are designed to be poisons to kill the pest for which they are used. There are, however, great ranges in the level of toxicity among different pesticides. It is imperative that persons working with pesticides have a broad general knowledge of the relative toxicity of at least the most common pesticides used.

Pesticide users should be concerned with the hazard associated with exposure as well as the toxicity of the chemical itself. Toxicity is the inherent capability of a substance to produce injury or death.

Hazard is a function of toxicity and exposure. The hazard can be expressed as the probability that injury will result from the use of the pesticide in a given formulation, quantity, or manner. The hazard might be specific in nature, as posing a toxicity problem to humans or to animals or in another instance cause injury to some plants (phytotoxicity).

A pesticide can be extremely toxic as a concentrate and possibly pose very little hazard to the user if: 1) used in a very dilute formulation; 2) used in formulation (granule) that is not readily absorbed through the skin or inhaled; 3) used only occasionally under conditions of no human exposure; and 4) used by experienced applicators that are properly equipped to handle the pesticide safely.

In another example, a pesticide may have a relatively low mammalian toxicity but present a hazard because it is used in the concentrated form, which may be readily absorbed or inhaled. It possibly may be hazardous to the nonprofessionals who are not aware of the possible hazards to which they are being exposed.

Human toxicity ratings would be the best guide to a pesticide's toxicity however, no actual scientific tests can be conducted in which humans are subjected to lethal doses of pesticides. There are some fragmentary data in regard to human toxicity ratings based on accidental exposures and suicides caused by some pesticides; however, essentially all pesticide toxicity ratings are based upon animal tests.

Toxicities of pesticides are generally expressed as LD or LC values, which means lethal dose or lethal concentration. There are several types of values such as acute oral LD_{50} which indicates the milligrams of the toxicant per kilogram (mg/kg) of the test animals body weight; or the acute dermal LD_{50} in terms of mg/kg; or inhalation levels LC_{50} in terms of micrograms of mist or dust per liter of air (µg/l) or parts per million by volume of gas or vapor (ppm). One microgram (µg) equals one millionth of a gram.

To determine LD_{50} or LC_{50} values, the dosage of a particular pesticide necessary to kill 50% of a large population of test animals under certain conditions is computed. An example may be a pesticide that has a LD_{50} of 10 which would indicate that 10 milligrams of this pesticide given to animals that weigh 1 kilogram each would kill 50% of the population.

Toxicity data based as LD_{50} values with animals involves several problems and should not be interpreted as exact values for human toxicity, but these values can be used as guides if considered with caution.

One of the first problems is the accidental hazard represented by any pesticide which depends more upon how it is used than how toxic it is.

Secondly, pesticide toxicity levels may vary according to the species of test animal, test method, sex of the species, whether the animals have been fasted or not, state of animal health, purity of the chemical tested, carrier in which the chemical is administered, route of administration, and length of time and frequency of exposure.

A third problem encountered when interpreting LD_{50} values is that the LD_{50} is only a statistic. It provides no information on the dosage that will be fatal to a specific individual in a large population of animals. Statistically however, the LD_{50} value is the most accurate means available to indicate the level of pesticide toxicity.

Fourth, it must be remembered that LD_{50} values are usually expressed in terms of single dosages or exposures only, such as: acute oral referring to a single dose taken or ingested by mouth; acute dermal referring to a single dose applied directly to and absorbed by the skin; and inhalation referring to exposure through breathing or inhaling. Thus, LD_{50} values give little or no information about the possible cumulative effects of a pesticide.

As an aid or guide to those unfamiliar with toxicity values, the following Table 1 groups and translates these figures into practical terms.

The relative acute toxic hazards of some pesticides to spraymen can be found in Table 2. The pesticides are categorized in descending order as most dangerous, dangerous, less dangerous, and least dangerous.

Toxicity Tables

The following pesticide toxicity tables 3-12 and information with some modifications are from the University of California Pesticide Information and Safety Manual July, 1968 and the Washington State Pest Control Handbook November, 1971.

The pesticides are listed alphabetically and cross indexed under type of pesticide. The approved common name (generic) is in lower case letters. Where no common name has been designated, the chemical name of the pesticide is given in lower case letters, or the trade name with capitalized first letters, followed by the trade mark symbol ® when the name has been registered. In some instances, other commonly used designations are listed such as: 2,4-D, 2,4,5-T, or PCNB. Frequently, one or more of the many trade names also are given following the approved common name or the chemical name of the pesticide, for the convenience of those unfamiliar with other names.

Prefixes used in naming pesticides alphabetized are: any prefix consisting of two or more letters, such as bis, di, tri, etc. Prefixes not alphabetized are: numbers and any prefix consisting of only one letter such as O, N, S, or P.

Dermal toxicity data for chemicals used in plant disease control (fungicides) as well as herbicides and plant growth regulators is limited.

Table 1. Guide to combined toxicity classes.

	Routes of Absorption			
	Acute oral LD_{50} values for animals mg/kg	Acute dermal LD_{50} values for animals mg/kg	Signal word or symbol on label	Probable lethal oral dose for man
High toxicity	1 to 50	20 or less to 200	Danger, poison Red skull and Crossbones symbol	A taste, a grain, a pinch, 1 teaspoon
Moderate toxicity	50 to 500	200 - 1000	Warning	1 teaspoon to 2 tablespoons or 1 ounce
Low toxicity	500 to 5000	1000 - 2000	Caution	1 ounce to 1 pint
Relatively Non-toxic	5000 to 15000	2000 - 20,000	-----	1 pint to 1 quart

Table 2. Estimated relative acute toxic hazards of pesticides to spraymen**

The estimates of hazards are based primarily on the observed acute dermal and to a less extent oral toxicity of these compounds to experimental animals. Use experience has also been considered. It should be noted that the classification into toxicity groups is both approximate and relative. These toxicity categories are not related to specific categories spelled out for label requirements.

MOST DANGEROUS	DANGEROUS	LESS DANGEROUS*	LEAST DANGEROUS
	Aldrin	Akton	Abate
Aldicarb (Temik)	Azodrin	Azinophos-Methyl (Guthion)	Alar
Carbofuran (Furadan)	Baygon (propoxur)	Binzpacryl (Morocide)	Aramite
Dasanit	Bidrin (dicrotophos)	BHC	Bromophos
Demeton (Systox)	Bux	Chlordane	Captan
Disulfoton (Di-Syston)	Carbophenothion (Trithion)	Ciodrin	Carbaryl (Sevin)
Dyfonate	Dichlorvos (DDVP)	Coumaphos (Co-Ral)	Chlorobenzilate
Lannate (methomyl)	Dieldrin	Diazinon	2,4-D
Mevinphos (Phosdrin)	Dioxathion (Delnav)	Dicapthon	DDT
Monitor	DNOC	Dichloroethyl ether	Dicofol (Kelthane)
Parathion	DNOSBP	Dichlorvos (DDVP)	Dilan
Phorate (Thimet)	Endrin	Dimethoate	Dinocap (Karathane)
Schradan (OMPA)	EPN	Dinobuton (Dessin)	Diquat
TEPP	Methyl parathion	Endosulfan (Thiodan)	Gardona (Rabon)
Zinophos (Cynem)	Nicotine	Ethion	Malathion
	Paraquat	Fenthion (Baytex)	Maneb
	Pentachlorophenol	Fundal (chlorphenamidine)	Methoxychlor
	Phosphamidon	Galecron (chlorphenamidine)	Mirex
	Zectram	Heptachlor	Morestan
	Zolone	Imidan	NAA
		Lead Arsenate	Omite
		Lindane	Perthane
		Naled (Dibrom)	Phostex
		Oxydemetonmethyl (Meta-Systox-R)	Piperonyl butoxide
		Ruelene (crufomate)	Ronnel (Korlan)
		Toxaphene	Rotenone
		Trichlorfon (Dipterex)	Sulphenone
		VC-13	TDE (DDD)
		Vapam	Tedradifon (Tedion)

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*The fumigant compounds acrylonitrile, D-D, or Vidden D, and Telone have toxicities which would indicate their placement in the "Less Dangerous" category. However, special note should be taken of the fact that the volatility of these compounds and their capacity to produce irritation of skin, eyes, and other tissues indicate that appropriate caution should be exercised in their use.

**From Washington State Pest Control Handbook, November, 1971.

Table 3. Toxicity values of insecticides and acaricides.

Chemicals	Acute LD_{50} values for rats in mg of substance per kg of body weight of test animal1/			
	Oral		Dermal	
	Males	Females	Males	Females
	mg/kg		*mg/kg*	
Abate ^{R}	3,600	.....	(4,000)	
aldicarb, Temik	0.79	0.65	3.0	2.5
aldrin	39	60	98	98
allethrin	.....	.....	(11,200)	
Aramite ^{R}	(3,900)		.....	.....
azinphosmethyl, Guthion ^{R}	13	11	220	220
Azodrin ^{R}	(21)		(354;rabbits)	
Bacillus thuringiensis, Thuricide ^{R}	(15,000)		.....	.....
Baygon ^{R}	95	104	(1,000)	
Baytex ^{R}, fenthion	215	245	330	330
Bidrin ^{R}	21	16	43	42
binapacryl, Morocide ^{R}	63	58	810	720
Bomyl ^{R}	(32)		(20-31;rabbits)	
boric acid	(3,000)2/		N3/	
calcium arsenate	.....	298	.....	2,400
carbaryl, Sevin ^{R}	850	500	4,000	4,000
carbophenothion, Trithion ^{R}	30	10	54	27
chlordane	335	430	840	690
chlorobenside, Mitox ^{R}	(3,000;mice)		.....	.....
chlorobenzilate	1,040	1,220	.....	.....
Ciodrin ^{R}	110	74	375	202
Compound 4072	15	13	31	30

1/ LD_{50} values are for rats, unless otherwise specified. Figures in parentheses ( ) indicate sex was not specified. The symbols means the LD_{50} is *higher than* the quoted figures, which were the highest amounts tested.

2/ As little as 30 mg/kg has proven fatal to a child.

3/ N indicates little or *no* skin irritation.

Table 3. Toxicity values of insecticides and acaracides (continued).

Chemicals	Acute LD_{50} values for rats in mg of substance per kg of body weight of test animal			
	Oral		Dermal	
	Males	Females	Males	Females
	mg/kg		*mg/kg*	
Co-Ral®, coumaphos	41	16	860	.....
cryolite, Kryocide®	(200)		.....	.....
Cygon®, dimethoate	215	.....	400	.....
DDD, TDE, Rothane®	(3,400)		(4,000;rabbits)	
DDT	113	118	.....	2,510
DDVP, dichlorvos, Vapona®	80	56	107	75
Delnav®, dioxathion	43	23	235	63
demeton, Systox®	6	2.5	14	8
Dessin, dinobuton	95	.....	844;rabbits	.....
diazinon	108	76	900	455
Dibrom®, naled	250	.....	800	.....
Di-Captan, dicapthon	400	330	790	1,250
dichlorvos, DDVP, Vapona®	80	56	107	75
dicofol, Kelthane®	1,100	1,000	1,230	1,000
dieldrin	46	46	90	60
Dilan®	600	475	6,900	5,900
Dimecron®, phosphamidon	24	24	143	107
dimethoate, Cygon®	215	.....	400	.....
dimetilan, Snip®	(50-64)		(2,000;rabbits)	
Dimite®	(500)		.....	.....
dinitrobutylphenol, DN-289®, Elgetol® 318, dinoseb	(37-60)		(500;guinea pigs)	
dinitrocresol, Sinox®, Elgetol® 30	(30-65)		>(600)	
dinitrocyclohexylophenol, DN-Dry Mix® No. 1	(50-125;mice)		.....	.....
dinobuton, Dessin	95	.....	884;rabbits	.....
dinocap, Karathane®	980	1,190	(9,400;rabbits)	
dinoseb, dinitrobutylphenol, DN-289®, Elgetol® 318	(37-60)		(500;guinea pigs)	
dioxathion, Delnav®	43	23	235	63
Dipterex®, trichlorfon, Dylox®	630	560	>2,000	>2,000

Table 3. Toxicity values of insecticides and acaricides (continued).

Chemicals	Acute LD$_{50}$ values for rats in mg of substance per kg of body weight of test animal			
	Oral		Dermal	
	Males	Females	Males	Females
	mg/kg		mg/kg	
disulfoton, Di-Syston®	7	2.3	15	6
DN-289®, Elgetol® 318, dinoseb, dinitrobutylphenol	(37-60)		(500;guinea pigs)	
DN-Dry Mix® No. 1, dinitrocyclohexylphenol	(50-125;mice)		.....	.....
Dri Die 67®, silica aerogel plus ammonium fluosilicate	3,160	.....	>(3,160;rabbits)	
Dylox®, Dipterex®, trichlorfon	630	560	>2,000	>2,000
Elgetol® 30, dinitrocresol, Sinox®	(30-65)		>(600)	
Elgetol® 318, dinitrobutylphenol, DN-289®, dinoseb	(37-60)		(500;guinea pigs)	
endosulfan, Thiodan®	43	18	130	74
endrin	18	8	18	15
EPN	36	8	230	25
ethion, Nialate®	65	27	245	62
fenthion, Baytex®	215	245	330	330
Furadan®, Nia 10242	(5)		(885;rabbits)	
Genite® 923	1,400	1,900	>(940;rabbits)	
Guthion®, azinphosmethyl	13	11	220	220
heptachlor	100	162	195	250
Imidan®	(147-284)		(3,160;rabbits)	
Karathane®, dinocap	980	1,190	(9,400;rabbits)	
Kelthane®, dicofol	1,100	1,000	1,230	1,000
Kepone®	125	125	>2,000	>2,000
Korlan®, ronnel, Trolene®	1,250	2,630	(2,000)	
Kryocide®, cryolite	(200)		.....	.....
lead arsenate	.....	1,050	.....	>2,400
lindane	88	91	1,000	900
malathion	1,375	1,000	>4,444	>4,444
Marlate®, methoxychlor	(6,000)		.....	6,000
Metacil®	30	30	.....	275
Meta-Systox®-R, oxydemetonmethyl	65	75	250	.....

Table 3. Toxicity values of insecticides and acaricides (continued).

Chemicals	Acute LD$_{50}$ values for rats in mg of substance per kg of body weight of test animal			
	Oral		Dermal	
	Males	Females	Males	Females
	mg/kg		mg/kg	
methoxychlor, Marlate ®	(6,000)		.....	>6,000
methyl parathion	14	24	67	67
Methyl Trithion ®	98	120	215	190
mevinphos, Phosdrin ®	6	3.7	4.7	4.2
mirex	740	600	>2,000	>2,000
Mitox ®, chlorobenside	>(3,000;mice)		.....	.....
Morestan ®	1,800	1,100	>2,000	>2,000
Morocide ®, binapacryl	63	58	810	720
Naled, Dibrom ®	250	.....	800	.....
Nia 10242, Furadan ®	(5)		(885;rabbits)	
Nialate ®, ethion	65	27	245	62
nicotine sulfate	.....	83	.....	285
OMPA, schradan	9	42	15	44
ovex, Ovotran ®	(2,050)		Causes Skin Irritation	
oxydemetonmethyl, Meta-Systox ®-R	65	75	250	.....
parathion	13	3.6	21	7
Paris Green	(22-100)		.....	>2,400
Pentac ®	3,160	.....	(3,160;rabbits)	
Perthane ®	>4,000	>4,000	.....	.....
phorate, Thimet ®	2.3	1.1	6	2.5
Phosdrin ®, mevinphos	6	3.7	4.7	4.2
phosphamidon, Dimecron ®	24	24	143	107
pyrethrum	.....	200	>(1,800)	
ronnel, Trolene ®, Korlan ®	1,250	2,630	(2,000)	
rotenone	(132)		>(1,000-3,000;rabbits)	
Rothane ®, TDE, DDD	(3,400)		(4,000;rabbits)	
Ruelene ®	635	460	(490;rabbits)	

Table 3. Toxicity values of insecticides and acaricides (continued).

Chemicals	Acute LD$_{50}$ values for rats in mg of substance per kg of body weight of test animal			
	Oral		Dermal	
	Males	**Females**	**Males**	**Females**
	mg/kg		*mg/kg*	
ryania	(750-1,200)		>(4,000;rabbits)	
sabadilla	(4,000)		.....	.....
schradan, OMPA	9	42	15	44
Sevin®, carbaryl	850	500	>4,000	>4,000
silica aerogel plus ammonium fluosilicate, Dri Die 67®	3,160	.....	>(3,160;rabbits)	
Sinox®, dinitrocresol, Elgetol®30	(30-65)		>(600)	
Snip®, dimetilan	(50-64)		(2,000;rabbits)	
sodium fluosilicate	(125)		.....	.....
Strobane®	(200)		.....	.....
Systox®, demeton	6	2.5	14	8
TDE, DDD, Rothane®	(3,400)		(4,000;rabbits)	
Tedion®, tetradifon	>(14,700)		>(10,000;rabbits)	
Temik, aldicarb	0.79	0.65	3.0	2.5
tepp	1	.....	2.4	.....
tetradifon, Tedion®	>(14,700)		>(10,000;rabbits)	
Thimet®, phorate	2.3	1.1	6	2.5
Thiodan®, endosulfan	43	18	130	74
thionazin, Zinophos®	6.4	3.5	17	11
Thuricide®, *Bacillus Thuringiensis*	>(15,000)		.....	.....
toxaphene	90	80	1,075	780
Tranid	30	19	>2,000	>2,000
trichlorfon, Dylox®, Dipterex®	630	560	>2,000	>2,000
Trithion®, carbophenothion	30	10	54	27
Trolene®, ronnel, Korlan R	1,250	2,630	(2,000)	
Vapona®, dichlorvos, DDVP	80	56	107	75
Zectran®	37	25	1,500-2,500	1,500-2,500
Zinophos®, thionazin	6.4	3.5	17	11

Table 4. Toxicity values of fungicides and other chemicals used in plant disease control.

Chemicals	Acute LD$_{50}$ values for rats in mg of substance per kg of body weight of test animal			
	Oral		Dermal	
	Males	Females	Males	Females
	mg/kg		mg/kg	
Acti-dione ®, ~~cycloheximide~~	(1.8-2.5)		S[2]	
Agri-mycin ®, streptomycin	(9,000;mice)		>(600)	
2-aminobutane, Tutane ®	(380)		M[3]	
Amobam, diammonium ethylene bisdithiocarbamate	>(450)		.....	.....
Anti-carie ®, HCB	Low Systemic Activity		M	
Arasan ®, thiram, TMTD	(780)		.....	.....
Benquinox, Cerenox ®	(100)		.....	.....
binapacryl, Morocide ®	63	58	810	720
biphenyl, diphenyl	(3,280)		.....	.....
bordeaux mixture, copper sulfate and lime	(300)		>(1,000)	
Bord oil, copper oleate	>(6,000)		.....	.....
Botran ®, dichloran	(4,040->10,000)		.....	.....
cadmium chloride, Caddy ®	(88)		.....	.....
calcium hypochlorite, Perchloron ®	Harmful if Swallowed		.....	.....
Calo-Clor ®, mercuric chloride	(37)		.....	.....
calomel, Calogreen ®	(210)		.....	.....
captan, Orthocide 406 ®	(9,000-15,000)		.....	.....
Cellu-quin, copper-8-quinolinolate	(5,000)		.....	.....
Cerenox ®, Benquinox	(100)		.....	.....
chloranil, Spergon ®	(4,000)		.....	.....
chloroneb, Demosan ®	>11,000	>11,000	>(5,000;rabbits)	
1-chloro-2-nitropropane, Lanstan ®	(197)		(362;rabbits)	

1/ LD$_{50}$ values are for rats, unless otherwise specified. Figures in parentheses () indicate sex was not specified. The symbol > means the LD$_{50}$ is *higher than* the quoted figures, which were the highest amounts tested.

2/ *S* indicates *severe* skin irritation.

3/ *M* indicates *mild* skin irritation.

Table 4. Toxicity values of fungicides and other chemicals used in plant disease control (continued).

Chemicals	Acute LD_{50} values for rats in mg of substance per kg of body weight of test animal			
	Oral		Dermal	
	Males	Females	Males	Females
	mg/kg		*mg/kg*	
copper oleate, Bord Oil	>(6,000)		.....	.....
copper-8-quinolinolate, Cellu-quin	(5,000)		.....	.....
copper sulfate and lime, bordeau mixture	(300)		>(1,000)	
Crag 341®, glyodin	(5,770)		*M*	
cycloheximide, Acti-dione®	(1.8-2.5)		*S*	
Cyprex®, dodine	(750-1,550)		.....	.....
Demosan®, chloroneb	>11,000	>11,000	>(5,000;rabbits)	
Dexon®	(60)		.....	.....
diammonium ethylene bisdithiocarbamate, Amobam	>(450)		.....	.....
dichlone, Phygon®	(1,300-2,250)		*M*	
dichloran, Botran®	(4,040->10,000)		.....	.....
Difolatan®	(4,600-6,200)		.....	.....
dinitrobutylphenol, DN-289®, dinoseb, Elgetol® 318	(37-60)		(500;guinea pigs)	
dinitrocresol, Sinox®, Elgetol® 30	(30-65)		>(600)	
dinitrocyclohexylphenol, DN-Dry Mix® No. 1	(50-125;mice)		.....	.....
dinocap, Karathane®	980	1,190	(9,400;rabbits)	
dinoseb, dinitrobutylphenol, DN-289®, Elgetol® 318	(37-60)		(500;guinea pigs)	
diphenyl, biphenyl	(3,280)		.....	.....
Dithane® D 14, nabam	(395)		>(1,000)	
DMTT, Mylone®	(500)		*M*	
DN-289®, Elgetol® 318, dinoseb, dinitrobutylphenol	(37-60)		(500;guinea pigs)	
DN-Dry Mix® No. 1, dinitrocyclohexylphenol	(50-125;mice)		.....	.....
dodine, Cyprex®	(750-1,550)		.....	.....
Dowicide 7®, PCP, Penchloro®	(125-210)		(150-350)	
Dowicide 1®, *O*-phenyl phenol	(2,480)		*M*	
Dowicide G®, sodium pentachlorophenate	(78-218)		(257)	
Dowicide A®, sodium-o-phenylphenate	(2,700)		*S*	

Table 4. Toxicity values of fungicides and other chemicals used in plant disease control (continued).

Chemicals	Acute LD_{50} values for rats in mg of substance per kg of body weight of test animal			
	Oral		Dermal	
	Males	Females	Males	Females
	mg/kg		mg/kg	
Du-Ter®, triphenyl tin hydroxide	108	.....	5,000; rabbits	5,000; rabbits
Dyrene®	(2,710)		*M*	
Elgetol® 30, dinitrocresol, Sinox®	(30-65)		>(600)	
Elgetol® 318, dinitrobutylphenol, DN-289®, dinoseb	(37-60)		(500;guinea pigs)	
ferbam, Fermate®	(17,000)		>(1,000)	
fixed coppers	(3,000-6,000)		.....	.....
folpet, Phaltan®	>(10,000)		*M*	
formaldehyde	(800)		*M*	
Fulex A-D-O®, 8-quinolinol sulfate	(1,200)		.....	.....
glyodin, Crag 341®	(3,170-5,770)		*M*	
Harven®, SDHA	(1,000)		.....	.....
HCB, Anti-carie®	Low Systemic Activity		*M*	
hexachlorophene, Nabac	(80-1,200)		*M*	
household bleach, sodium hypochlorite	Harmful if Swallowed		.....	.....
Isothan Q15®, laurylisoquinolin bromide	(230)		.....	.....
Karathane®, dinocap	980	1,190	(9,400;rabbits)	
Lanstan®, 1-chloro-2-nitropropane	(197)		(362;rabbits)	
laurylisoquinolin bromide, Isothan Q15®	(230)		.....	.....
lime sulfur, Orthorix®	Low		*S*	
maneb, Manzate®	(7,500)		(1,000)	
mercuric chloride, Calo-Chlor®	(37)		.....	.....
Metiram, Polyram®	(6,400)		.....	.....
MIT, Trapex®, Vorlex®	(305)		.....	.....
Morocide®, binapacryl	63	58	810	720
Mylone®, DMTT	(500)		*M*	
Nabac, hexachlorophene	(80-1,200)		*M*	

Table 4. Toxicity values of fungicides and other chemicals used in plant disease control (continued).

Chemicals	Acute LD_{50} values for rats in mg of substance per kg of body weight of test animal			
	Oral		Dermal	
	Males	Females	Males	Females
	mg/kg		mg/kg	
Nabam, Dithane ® D 14	(395)		>(1,000)	
nickel sulfate	(62)[4]		.....	.....
organic mercury compounds	(30)		.....	.....
Orthocide 406 ®, captan	(9,000-15,000)		.....	.....
Orthorix ®, lime sulfur	Low		*S*	
Parzate ®, zineb	>(5,200)		>(1,000)	
PCNB, Terraclor ®	(1,750-2,000)		.....	.....
PCP, Penchloro ®, Dowicide 7 ®	(125-210)		(150-350)	
Perchloron ®, calcium hypochlorite	Harmful if Swallowed		.....	.....
Phaltan ®, folpet	>(10,000)		*M*	
Phygon ®, dichlone	(1,300-2,250)		*M*	
O-phenyl phenol, Dowicide 1 ®	(2,480)		*M*	
Piperalin, Pipron ®	(2,500)		>(2,500;rabbits)	
Polyram ®, Metiram	(6,400)		.....	.....
8-quinolinol sulfate, Fulex A-D-O ®	(1,200)		.....	.....
SDHA, Harven ®	(1,000)		.....	.....
Sinox ®, dinitrocresol, Elgetol ® 30	(30-65)		>(600)	
SMDC, Vapam ®	(820)		.....	.....
sodium hypochlorite, household bleach	Harmful if Swallowed		.....	.....
sodium pentachlorophenate, Dowicide G ®	(78-218)		(257)	
sodium-o-phenylphenate, Dowicide A ®	(2,700)		*S*	
Spergon ®, chloranil	(4,000)		.....	.....
stendomycin	(400)		.....	.....
streptomycin, Agri-mycin ®	(9,000;mice)		>(600)	
Terraclor ®, PCNB	(1,750-2,000)		.....	.....
thiram, TMTD, Arasan ®	(780)		.....	.....

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[4] $LD_{s.c.}$ which means lethal dose administered subcutaneously, i.e. *under* the skin.

Table 4. Toxicity values of fungicides and other chemicals used in plant disease control (continued).

Chemicals	Acute LD_{50} values for rats in mg of substance per kg of body weight of test animal			
	Oral		Dermal	
	Males	Females	Males	Females
	mg/kg		mg/kg	
Trapex®, MIT, Vorlex®	(305)		.....	.....
triphenyl tin hydroxide, Du-Ter®	108	.....	5,000; rabbits	5,000; rabbits
Tutane®, 2-aminobutane	(380)		M	
Vapam®, SMDC	(820)		.....	.....
Vorlex®, MIT, Trapex®	(305)		.....	.....
Zerlate®, ziram	(1,400)		>(1,000)	
zineb, Parzate®	>(5,200)		>(1,000)	
ziram, Zerlate®	(1,400)		>(1,000)	

Table 5. Toxicity values of herbicides.

Chemicals	Acute LD_{50} values for rats in mg of substance per kg of body weight of test animal[1]			
	Oral		Dermal	
	Males	Females	Males	Females
	mg/kg		mg/kg	
acrolein, Aqualin®	(46)		*S*[2]	
Aero® Cyanate, potassium cyanate, KOCN	(841-850)		.....	.....
Aero® Cyanamide, calcium cyanamide	(1,400;rabbits)		.....	.....
Alanap®, NPA, N-1-naphthyl phthalamic acid	(2,000-8,500)		*N*[3]	
Alipur-O, cycluron	(1,500)		.....	.....
allyl alcohol	(64)		(89;rabbits)	
amiben	(3,500-5,620)		(3,136;rabbits)	
amitrole, Amizol®	(5,000-14,700)		>(10,000;rabbits)	
amitrole and ammonium thiocyanate, Cytrol®	(5,000)		.....	.....
ammonium sulfamate, AMS, Ammate®	(1,600-3,900)		*N*	
Amizol®, amitrole	(5,000-14,700)		>(10,000;rabbits)	
AMS, ammonium sulfamate, Ammate®	(1,600-3,900)		*N*	
Ansar® 184, disodium methanearsonate, Sodar®	(2,800)		*N*	
Ansar® 157, MAMA	(750)		*N*	
Ansar® 170, MSMA, monosodium acid methanearsonate	(700-1,800)		.....	.....
Aqualin®, acrolein	(46)		*S*	
Arsan®, cacodylic acid, Phytar® 138	(1,350)		*N*	
Atlacide®, sodium chlorate	(1,350-1,940) (Fatal to Cats)		*M*[4]	
Atlas® A, sodium arsenite	(10-50)		*M*	
atratone	(2,400)		.....	.....

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[1] LD_{50} values are for rats, unless otherwise specified. Figures in parentheses () indicate sex was not specified. The symbol > means the LD_{50} is *higher than* the quoted figures, which were the highest amounts tested.

[2] *S* indicates *severe* skin irritation.

[3] *N* indicates little or *no* skin irritation.

[4] *M* indicates *mild* skin irritation.

Table 5. Toxicity values of herbicides (continued).

Chemicals	Acute LD$_{50}$ values for rats in mg of substance per kg of body weight of test animal			
	Oral		Dermal	
	Males	Females	Males	Females
	mg/kg		*mg/kg*	
atrazine	(3,080)		*N*	
Avadex®, diallate	(395)		*M*	
Avadex BW®, triallate	(1,675-2,161)		(2,225-4,050; rabbits)	
Balan, benefin	>(10,000)		*N*	
Bandane®	(575)		>(12,000)	
Banvel® D, dicamba	(1,040)		.....	.....
barban, Carbyne®	(1,300)		*N*	
Baron®, erbon	(1,120)		*M*	
benefin, Balan	>(10,000)		*N*	
bensulide, Betasan®, Prefar®	770	.....	>(3,950;rabbits)	
Benzac® 1281, 2,3,6-TBA acids and salts, Trysben®	(750-1,644)		(1,000)	
Betasan®, bensulide, Prefar®	770	.....	>(3,950;rabbits)	
Bluestone, copper sulfate	(Est. 15,000; lethal-humans)		*S*	
bromocil, Hyvar®-X	(5,200)		*M*	
bromoxynil, Buctril®	(270)		.....	.....
Butyrac 118®, 2,4-DB	(400;mice)		.....	.....
cacodylic acid, Arsan®, Phytar® 138	(1,350)		*N*	
calcium arsenate, Kalo®	(35-100)		*M*	
calcium chlorate	(4,500)		.....	.....
calcium cyanamide, Aero® Cyanamide	(1,400;rabbits)		.....	.....
Can-Trol®, MCPB, sodium salt	(700)		(1,000)	
Caparol® 80 W, prometryne	(3,750)		*N*	
Carbyne®, barban	(1,300)		*N*	
Casoron®, dichlobenil	>(3,160)		(550;rabbits)	
CDAA, Randox®	(700)		*M*	

Table 5. Toxicity values of herbicides (continued).

Chemicals	Acute LD_{50} values for rats in mg of substance per kg of body weight of test animal			
	Oral		Dermal	
	Males	Females	Males	Females
	mg/kg		mg/kg	
CDEC, Vegadex®	(850)		M	
chlordane	335	430	840	690
chloro IPC®, CIPC	(5,000-8,000)		N	
copper sulfate, Bluestone	(Est. 15,000; lethal-humans)		S	
4-CPA, parachlorophenoxyacetic acid	(300-700)		.....	.....
Crab-E-Rad®, octyl ammonium methyl arsonate, Diama®	(600-794)		.....	.....
Crag DCU, dichloral urea	>(31,600)		.....	.....
cycluron, Alipur-O	(1,500)		.....	.....
Cytrol®, amitrole and ammonium thiocyanate	(5,000)		.....	.....
dalapon, Dowpon®, Radapon®	(3,860-9,000)		M	
Dacthal®	>3,000	.....	>(10,000;rabbits)	
2,4-D acid, Weedone® 638	(375)		(1,500)	
2,4-DB, Butyrac 118®	(400;mice)		.....	.....
2,4-D butyl ester, Esteron® 76 BE	(620)		(800)	
2,4-DEP, Falone® 44E	(850)		M	
2,4-DES, sesone	(1,000)		.....	.....
Des-I-Cate®, endothall	(38-206)		(750)	
Diama®, octyl ammonium methyl arsonate, Crab-E-Rad®	(600-794)		.....	.....
diallate, Avadex®	(395)		M	
dicamba, Banvel® D	(1,040)		.....	.....
dichlobenil, Casoron®	(3,160)		(500;rabbits)	
dichloral urea, Crag DCU®	>(31,600)		.....	.....
dichlorprop, 2-(2,4-DP) acid	(400;mice)		(1,400)	
dicryl	(1,800-3,160)		(10,000;rabbits)	
diphenamid, Dymid®, Enide®	(1,048-1,798)		>(6,320)	
diquat	(400-440)		>(500;rabbits)	

Table 5. Toxicity values of herbicides (continued).

Chemicals	Acute LD_{50} values for rats in mg of substance per kg of body weight of test animal			
	Oral		Dermal	
	Males	Females	Males	Females
	mg/kg		mg/kg	
disodium methanearsonate, Ansar® 184, Sodar®	(2,800)		*N*	
2,4-D isopropyl ester, Esteron® 76-E	(700)		.....	.....
diuron, Karmex®	(3,400)		*M*	
DMTT, Mylone®	(500-650)		*M*	
DN-289®, dinitrobutylphenol, dinoseb, Elgetol® 318	(37-60)		(500;guinea pigs)	
Dowicide® 7, Penta, PCP	(125-210)		(150-350)	
Dowicide® G, Penta sodium salt	(78-218)		(257)	
Dowpon®, dalapon, Radapon®	(3,860-9,000)		*M*	
2-(2,4-DP) acid, dichlorprop	(400;mice)		(1,400)	
2,4-D sodium salt	(666-805)		.....	.....
Dybar®, fenuron	(6,400)		*M*	
Dymid®, diphenamid, Enide®	(1,048-1,798)		>(6,320)	
endothall, Des-I-Cate®	(38-206)		(750)	
Enide®, diphenamid, Dymid®	(1,048-1,798)		>(6,320)	
Eptam®	1,630	3,160	(2,641;rabbits)	
erbon, Baron®	(1,120)		*M*	
Esteron® 76 BE, 2,4-D butyl ester	(620)		(800)	
Esteron® 76 E, 2,4-D isopropyl ester	(700)		.....	.....
Falone®-44E, 2,4-DEP	(850)		*M*	
fenac	(1,780-3,000)		>(3,160;rabbits)	
fenuron, Dybar®	(6,400)		*M*	
fenuron TCA, Urab®	5,700	4,000	*M*	
Herban®, norea	(1,470)		(23,000)	
hexachloroacetone, HCA® Weed Killer	(1,290-1,550)		*M*	
Hyvar®, isocil	(3,250)		*M*	
Hyvar®-X, bromacil	(5,200)		*M*	
IPC, propham	(9,000)		*N*	

Table 5. Toxicity values of herbicides (continued).

Chemicals	Acute LD_{50} values for rats in mg of substance per kg of body weight of test animal: Oral, Males (mg/kg)	Oral, Females	Dermal, Males (mg/kg)	Dermal, Females
isocil, Hyvar ®	(3,250)		*M*	
Kalo ®, calcium arsenate	(35-100)		*M*	
Karmex ®, diuron	(3,400)		*M*	
Kloben ®, neburon	>(11,000)		*M*	
KOCN, potassium cyanate, Aero ® Cyanate	(841-850)		.....	.....
Kuron ®, silvex, 2-(2,4,5-TP) ester	(650)		.....	.....
linuron, Lorox ®	(1,500)		*M*	
maleic hydrazide amine, MH ®-30	(2,340)		(4,000;rabbits)	
maleic hydrazide sodium salt, MH ®-40	(6,950)		(4,000;rabbits)	
MAMA, Ansar ® 157	(750)		*N*	
MCPA acid	(700)		>(1,000)	
MCPA amine	(1,200)		>(1,000)	
MCPB sodium salt, Can-Trol ®	(700)		(1,000)	
MCPP sodium salt, Mecoprop	(650)		.....	.....
MH ®-30, maleic hydrazide amine	(2,340)		(4,000;rabbits)	
MH ®-40, maleic hydrazide sodium salt	(6,950)		(4,000;rabbits)	
molinate, Ordram ®	501	660	>(2,000;rabbits)	
monosodium acid methanearsonate, MSMA, Ansar ® 170	(700-1,800)		.....	.....
monuron, Telvar ®	(3,500-3,600)		*N*	
monuron TCA, Urox ®	3,700	2,300	>(1,000)	
MSMA, monosodium acid methanearsonate, Ansar ® 170	(700-1,800)		.....	.....
Mylone ®, DMTT	(500-650)		*M*	
neburon, Kloben ®	>(11,000)		*M*	
N-1-naphthyl phthalamic acid, Alanap ®, NPA	(2,000-8,500)		*N*	
nitraline, Planavin ®	(2,000)		(2,000;rabbits)	
norea, Herban ®	(1,470)		(23,000)	
NPA, Alanap ®, N-1-naphthyl phthalamic acid	(2,000-8,500)		*N*	

Table 5. Toxicity values of herbicides (continued).

Chemicals	Acute LD_{50} values for rats in mg of substance per kg of body weight of test animal			
	Oral		Dermal	
	Males	Females	Males	Females
	mg/kg		mg/kg	
octyl ammonium methyl arsonate, Diama®, Crab-E-Rad®	(600-794)		.....	.....
Ordram®, molinate	501	660	>(2,000;rabbits)	
parachlorophenoxyacetic acid, 4-CPA	(300-700)		.....	.....
paraquat	(157)		*M*	
PCP, Penta, Dowicide® 7	(125-210)		(150-350)	
pebulate, Tillam®	1,120	.....	>(2,936;rabbits)	
Penta, Dowicide® 7, PCP	(125-210)		(150-350)	
Penta sodium salt, Dowicide® G	(78-218)		(257)	
phenyl mercuric acetate, PMA, Scutl®	(30)		*S*	
Phytar® 138, cacodylic acid, Arsan®	(1,350)		*N*	
picloram, Tordon®	.....	8,200	>(4,000;rabbits)	
piperalin, Pipron®	(2,500)		>(2,500;rabbits)	
Planavin®, nitraline	(2,000)		(2,000;rabbits)	
polychlorobenzoic acid, Zobar®	(960-1,140)		*M*	
potassium cyanate, KOCN, Aero® Cyanate	(841-850)		.....	.....
PMA, Scutl®, phenyl mercuric acetate	(30)		*S*	
Pramitol®, prometone	(2,980)		*N*	
Prefar®, bensulide, Betasan®	770	.....	(3,950;rabbits)	
prometon, Pramitol®	(2,980)		*N*	
prometryne, Caparol® 80W	(3,750)		*N*	
propanil, Stam® F-34, Rogue®	(560-1,384)		(7,080;rabbits)	
propazine	>(5,000)		*N*	
propham, IPC	(9,000)		*N*	
pyrazon, Pyramin®	4,200	2,500	*M*	
Radapon®, dalapon, Dowpon®	(3,860-9,000)		*M*	
Randox®, CDAA	(700)		*M*	
Rogue®, propanil, Stam® F-34	(560-1,384)		(7,080;rabbits)	

Table 5. Toxicity values of herbicides (continued).

Chemicals	Acute LD_{50} values for rats in mg of substance per kg of body weight of test animal			
	Oral		Dermal	
	Males	Females	Males	Females
	mg/kg		*mg/kg*	
Scutl ®, PMA, phenyl mercuric acetate	(30)		*S*	
sesone, 2,4-DES	(1,000)		.....	.....
siduron, Tupersan ®	>(7,500)		>(5,500)	
silvex, 2-(2,4,5-TP) ester, Kuron ®	(650)		.....	.....
simazine	>(5,000)		*N*	
SMDC, Vapam ®, VPM ®	(820)		(800;rabbits)	
Sodar ®, disodium methanearsonate, Ansar ® 184	(2,800)		*N*	
sodium arsenite, Atlas ® A	(10-50)		*M*	
sodium chlorate, Atlacide ®	(1,350-1,940; fatal-cats)		*M*	
sodium TCA	(3,370-5,000)		*M*	
Stam ® F-34, propanil, Rogue ®	(560-1,384)		(7,080;rabbits)	
sulfuric acid	(1 oz. lethal to humans)		*S*	
2,4,5-T acids and esters	(481-500)		.....	.....
2,3,6-TBA acids and salts, Trysben ®, Benzac ® 1281	(750-1,644)		(1,000)	
Telvar ®, monuron	(3,500-3,600)		*N*	
Tillam ®, pebulate	1,120	.....	>(2,936;rabbits)	
Tordon ®, picloram	.....	8,200	>(4,000;rabbits)	
2-(2,4,5-TP) ester, silvex, Kuron ®	(650)		.....	.....
Treflan ®, trifluralin	(3,700->10,000)		>(5,000)	
triallate, Avadex ® BW	(1,675-2,161)		(2,225-4,050; rabbits)	
trifluralin, Treflan ®	(3,700->10,000)		>(5,000)	
Trysben ®, Benzac ® 1281, 2,3,6-TBA acids and salts	(750-1,644)		(1,000)	
Tupersan ®, siduron	>(7,500)		>(5,500)	
Urab ®, fenuron TCA	5,700	4,000	*M*	

Table 5. Toxicity values of herbicides (continued).

Chemicals	Acute LD_{50} values for rats in mg of substance per kg of body weight of test animal			
	Oral		Dermal	
	Males	Females	Males	Females
	mg/kg		mg/kg	
Urox®, monuron TCA	3,700	2,300	>(1,000)	
Vapam®, VPM®, SMDC	(820)		(800;rabbits)	
Vegadex®, CDEC	(850)		*M*	
VPM®, Vapam®, SMDC	(820)		(800;rabbits)	
Weedone® 638, 2,4-D acid	(375)		(1,500)	
Zobar®, polychlorobenzoic acid	(960-1,140)		*M*	

Table 6. Toxicity values of plant growth regulators.

Chemicals	Acute LD_{50} values for rats in mg of substance per kg of body weight of test animal[1/]			
	Oral		Dermal	
	Males	Females	Males	Females
	mg/kg		mg/kg	
Alanap ®, N-1-naphthyl phthalamic acid, NPA	(2,000-8,500)		N[2/]	
Alar ®, N-dimethylaminosuccinamic acid	(8,400)		.....	.....
Amid-Thin W, 1-naphthyl acetamid	(500-5,000)		.....	.....
Brellin, gibberellic acid, Gibrel	(6,300)		.....	.....
carbaryl, Sevin ®	850	500	> 4,000	> 4,000
chloro-IPC ^{R}, CIPC	(5,000-8,000)		N	
Chlorothene ®, 1,1,1-trichloroethane	(5,660-12,300)		>(500)	
CIPC, chloro-IPC ®	(5,000-8,000)		N	
4-CPA, parachlorophenoxyacetic acid	(300-700)		.....	.....
2,4-D, 2,4-dichlorophenoxyacetic acid	(375)		(1,500)	
N-dimethylaminosuccinamic acid, Alar ®	(8,400)		.....	.....
dinitrobutylphenol, DN-289 ®, Elgetol ® 318, dinoseb	(37-60)		(500;guinea pigs)	
dinitrocresol, Sinox ®, Elgetol ® 30	(30-65)		>(600)	
dinoseb, dinitrobutylphenol, DN-289 ®, Elgetol ® 318	(37-60)		(500;guinea pigs)	
Duraset ® 20W, N-metatolyphthalamic acid	(5,230)		N	
Elgetol ® 30, dinitrocresol, Sinox ®	(30-65)		>(600)	
Elgetol ® 318, dinitrobutylphenol, DN-289 ®, dinoseb	(37-60)		(500;guinea pigs)	
Esteron ® 245 O.S., 2,4,5-T	(300)		.....	.....
ethoxyquin, Stop-scald	(800-1,000)		.....	.....
ethylene chlorohydrin	(95)		S[3/]	
gibberellic acid, Gibrel, Brellin	(6,300)		.....	.....
Klingtite, naphthalene acetic acid, NAA	(1,000)		.....	.....

[1/] LD_{50} values are for rats, unless otherwise specified. Figures in parentheses () indicate sex was not specified. The symbol > means the LD_{50} is *higher than* the quoted figures, which were the highest amounts tested.

[2/] *N* indicates little or *no* skin irritation.

[3/] *S* indicates *severe* skin irritation.

Table 6. Toxicity values of plant growth regulators (continued).

Chemicals	Acute LD$_{50}$ values for rats in mg of substance per kg of body weight of test animal			
	Oral		Dermal	
	Males	Females	Males	Females
	mg/kg		mg/kg	
Kuron ®, silvex, 2-(2,4,5-TP) ester	(650)		.....	.....
maleic hydrazide amine, MH ® 30	(2,340)		(4,000;rabbits)	
maleic hydrazide sodium salt, MH ® 40	(6,950)		(4,000;rabbits)	
MH ® 30, maleic hydrazide amine	(2,340)		(4,000;rabbits)	
MH ® 40, maleic hydrazide sodium salt	(6,950)		(4,000;rabbits)	
N-metatolylphthalamic acid, Duraset ® 20W	(5,230)		*N*	
NAA, naphthalene acetic acid, Klingtite	(1,000)		.....	.....
1-naphthyl acetamide, Amid-Thin W	(500-5,000)		.....	.....
N-1-naphthyl phthalamic acid, Alanap ®, NPA	(2,000-8,500)		*N*	
parachlorophenoxyacetic acid, 4-CPA	(300-700)		.....	.....
Sevin ®, carbaryl	850	500	> 4,000	> 4,000
silvex, Kuron ®, 2-(2,4,5-TP) ester	(650)		.....	.....
Sinox ®, dinitrocresol, Elgetol ® 30	(30-65)		> (600)	
Stop-scald, ethoxyquin	(800-1,000)		.....	.....
1,1,1-trichloroethane, Chlorothene ®	(5,660-12,300)		> (500)	
2,4,5-T, Esteron ® 245 O.S.	(300)		.....	.....
2-(2,4,5-TP) ester, silvex, Kuron ®	(650)		.....	.....

Table 7. Toxicity values of defoliants and desiccants.

Chemicals	Acute LD_{50} values for rats in mg of substance per kg of body weight of test animal[1]			
	Oral		Dermal	
	Males	Females	Males	Females
	mg/kg		*mg/kg*	
Aero® Cyanamide, calcium cyanamide	(1,400;rabbits)		.....	.....
Arsan®, cacodylic acid, Phytar® 138	(1,350)		*N*[2]	
arsenic acid, Desiccant®, L-10	(8,0;rabbits)[3]		.....	.....
Atlas® A, sodium arsenite	(10-50)		*M*[4]	
cacodylic acid, Phytar® 138, Arsan®	(1,350)		*N*	
calcium cyanamide, Aero® Cyanamide	(1,400;rabbits)		.....	.....
DEF®-defoliant	(325)		.....	>1,000
De-Fol-Ate®, magnesium chlorate	(5,250)		.....	.....
Des-I-Cate®, endothall	(38-206)		(750)	
Desiccant® L-10, arsenic acid	(8.0;rabbits)[3]		.....	.....
dinitrobutylphenol, DN-289®, Elgetol® 318, dinoseb	(37-60)		(500;guinea pigs)	
diquat	(400-440)		(500;rabbits)	
DN-289®, dinitrobutylphenol, Elgetol® 318, dinoseb	(37-60)		(500;guinea pigs)	
endothall, Des-I-Cate®	(38-206)		(750)	
Folex®, Merphos	1,272	.....	(4,686-10,000; rabbits)	
hexachloroacetone, HCA® Seed Crop Desiccant	(1,290-1,550)		*M*	
magnesium chlorate, De-Fol-Ate®	(5,250)		.....	.....
Merphos, Folex®	1,272	.....	(4,686-10,000; rabbits)	
Phytar® 138, Arsan®, cacodylic acid	(1,350)		*N*	

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[1] LD_{50} values are for rats, unless otherwise specified. Figues in parentheses () indicate sex was not specified. The symbol > means the LD_{50} is *higher than* the quoted figures, which were the highest amounts tested.

[2] *N* indicates little or *no* skin irritation.

[3] Administered intravenously.

[4] *M* indicates *mild* skin irritation.

Table 7. Toxicity values of defoliants and desiccants (continued).

Chemicals	Acute LD_{50} values for rats in mg of substance per kg of body weight of test animal			
	Oral		Dermal	
	Males	Females	Males	Females
	mg/kg		mg/kg	
Shed-A-Leaf ®, sodium chlorate	(1,350-1,940; fatal to cats)		*M*	
sodium arsenite, Atlas ® A	(10-50)		*M*	
sodium chlorate, Shed-A-Leaf ®	(1,350-1,940; fatal to cats)		*M*	
sulfuric acid	1 oz. lethal to humans		*S*[5]	

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[5] *S* indicates *severe* skin irritation.

Table 8. Toxicity values of rodenticides.

Chemicals	Acute Oral LD_{50} values in mg of substance per kg of body weight of test animals	
	LD_{50} mg/kg	Test animals
antu, Bantu, Rattrack	0.38	Dogs
	2	Lethal to Norway Rats
	4,250	Monkeys
Arsenic Trioxide, White Arsenic	13	Rats
	100-500	Humans
Bantu, antu, Rattrack	0.38	Dogs
	2	Lethal to Norway Rats
	4,250	Monkeys
barium carbonate	400-4,000	Fatal to Humans
	630-750	Fatal to Rats
Compound 1080 ®, sodium fluoroacetate	0.1	Dogs
	0.5-2	Humans
	1-4	Rats
	5-10	Birds
Cook's Gopher Tabs ®, strychnine alkaloid	1-30	Rats
	4-24	Rabbits
	30-60	Lethal to Humans
Gophacide ®	3.7-7.8	Rats
norbormide, Raticate ®	5	White Rats
	12	Norway Rats
	1,000	No effect on cats, dogs, monkeys, chickens or turkeys
phosphorus	50-100	Fatal to Humans
Raticate ®, norbormide	5	White Rats
	12	Norway Rats
	1,000	No effect on cats, dogs, monkeys, chickens or turkeys

Table 8. Toxicity values of rodenticides (continued).

Chemicals	Acute Oral LD$_{50}$ values in mg of substance per kg of body weight of test animals	
	LD$_{50}$ mg/kg	Test animals
Rattrack, Bantu, antu	0.38	Dogs
	2	Lethal to Norway Rats
	4,250	Monkeys
sodium fluoroacetate, Compound 1080®	0.1	Dogs
	0.5-2	Humans
	1-4	Rats
	5-10	Birds
strychnine alkaloid, Cook's Gopher Tabs®	1-30	Rats
	4-24	Rabbits
	30-60	Lethal to Humans
thallium sulfate	25-31	Rats
	>500[1]	Fatal to Humans
White Arsenic, Arsenic Trioxide	13	Rats
	100-500	Humans
zinc phosphide	40-46	Rats
Anticoagulants	Note: The following anticoagulant-type rodenticides as normally sold in their diluted form are relatively nontoxic to humans in single oral doses. They must be consumed repeatedly over an extended period of time before they will produce any marked effect on humans.	
coumafuryl, Fumarin®	200	Rats
Diphacin® 120, diphacinone	15	Cats 14 days
	0.2 chronic	Rats 14 days

1/ The symbol > means the LD$_{50}$ is *less than* the quoted figure.

Table 8. Toxicity values of rodenticides (continued).

Chemicals	Acute Oral LD_{50} values in mg of substance per kg of body weight of test animals	
	LD_{50} mg/kg	Test animals
Fumarin®, coumafuryl	200	Rats
Fumasol, water soluble salt of Fumarin®	400	Mammals
pindone, Pival®	50	Rats
PMP®	Similar to Pival®	Rats
Prolin®	Similar to warfarin	Rats
warfarin	1	Rats 4-5 days
	3	Cats, Dogs 5 days
	1	Swine 5 days
	25	Swine single dose
	35	Cats single dose

VOLATILE CHEMICALS USED IN THE CONTROL OF INSECTS, DISEASE, NEMATODES, RODENTS AND WEED SEEDS [1/]

Chronic vapor toxicity to man is given in terms of parts per million (ppm) i.e., parts of vapor or gas per million parts of air by volume at 25° C and 760 mm Hg. pressure; or milligram per cubic meter (mg/m^3), i.e., approximate milligrams of particulate, mist or dust, per cubic meter of air. The values given are known as threshold limit values (TLVs) and refer to a toxic exposure for 5 days a week, 8 hours a day (Table 9.).

However, those compounds followed by the designation "C" refer to "ceiling" values that should not be exceeded; all values so designated should fluctuate *below* the listed value. In general, the bases for assigning or not assigning a "C" value rests on whether or not concentrations above a proposed limit for periods up to 15 *minutes* may result in: (a) intolerable irritation, (b) chronic or irreversible tissue change, or (c) narcosis, i.e., a state of unconsciousness or arrested activity of sufficient degree to increase accident proneness, impair self-rescue or materially reduce work efficiency.

Those substances followed by the designation "Skin" refer to the potential contribution to the over-all exposure by the cutaneous route, i.e., through the skin, including mucuous membranes and eye, either air-borne, or more particularly, by direct contact with the substance. Vehicles, i.e., solvents, carriers, etc., can alter skin absorption. This attention-calling designation is intended to suggest appropriate measures for the prevention of cutaneous absorption so that the threshold limit is not invalidated. These threshold limit values (TLVs) are not intended for use, or for modification for use as (1) a relative index of toxicity, by making a ratio of two limits, (2) in the evaluation or control of community air pollution or air pollution nuisances, (3) in estimating the toxic potential of continuous uninterrupted exposures. Furthermore, it should be pointed out that TLVs, as adopted by the American Conference of Governmental Industrial Hygienists, are not based solely on the toxicity of a particular compound but that the limits based on physical irritation should be considered no less binding than those based on physical impairment; growing bodies of evidence indicate that physical irritation may promote and accelerate physical impairment.

These values are reviewed annually by the Committee on Threshold Limits, appointed by the American Conference of Governmental Industrial Hygienists, for revision or additions, as further information becomes available.

[1/] From Pesticide Information and Safety Manual, Univ. of Calif. Agricultural Extension Service, July, 1968.

Table 9. Threshold limit values of commodity or space fumigants.

Chemicals	ppm of the substance per million parts air
acrylonitrile, VCN, vinyl cyanide; Skin	20.0
aluminum phosphide, Phosphine	0.3
benzene; "C" Skin	25.0
Bromofume®, ethylene dibromide, EDB; "C" Skin	25.0
bromomethane, methyl bromide; "C" Skin	20.0
calcium cyanide (as CN), Cyanogas®; Skin	5.0
carbon bisulfide, carbon disulfide; Skin	20.0
Carbon tetrachloride; Skin	10.0
chloroform	50.0
chloropicrin, Larvacide®, Picfume®	0.1
Chlorothene®, 1,1,1-trichloroethane	350.0
Cyanogas®, calcium cyanide (as CN); Skin	5.0
1,2-dichloroethane, EDC	50.0
dichloromethane	500.0
1,1-dichloro-1-nitroethane, Ethide®; "C"	10.0
EDB, ethylene dibromide, Bromofume®; "C" Skin	25.0
EDC, 1,2-dichloroethane	50.0
Ethide®, 1,1-dichloro-1-nitroethane; "C"	10.0
ethyl formate	100.0
ethylene dibromide, Bromofume®, EDB; "C" Skin	25.0
ethylene oxide, Oxirane	50.0
HCN, hydrocyanic acid, Skin	10.0
Larvacide®, chloropicrin, Picfume®	0.1
methyl bromide, bromomethane; "C" Skin	20.0
naphthalene	10.0
Oxirane, ethylene oxide	50.0
paradichlorobenzene, Paracide®, Santochlor®, PDB	75.0
Phosphine, aluminum phosphide	0.3
Picfume®, chloropicrin, Larvacide®	0.1
propylene oxide	100.0
Santochlor®, paradichlorobenzene, Paracide®, PDB	75.0
sulfur dioxide	5.0
sulfuryl fluoride, Vikane®	5.0
tetrachloroethylene	100.0
1,1,1-trichloroethane, Chlorothene®	350.0
VCN, acrylonitrile, vinyl cyanide; Skin	20.0
Vikane®, sulfuryl fluoride	5.0
vinyl cyanide, acrylonitrile, VCN; Skin	20.0

Table 10. Threshold limit values of nematocides.

Chemicals	ppm of the substance per million parts air
Bromofume®, ethylene dibromide, EDB; "C" Skin	25.0
bromomethane; "C" Skin	20.0
D-D®, 1,3-dichloropropene and 1,2-dichloropropane mixture, Vidden® D	1.0
1,2-dibromo-3-chloropropane, Fumazone®, Nemagon®	1.0
1,3-dichloropropene and 1,2-dichloropropane mixture, D-D®, Vidden® D	1.0
dichloropropenes mixture, Telone®	1.0
EDB, ethylene dibromide, Bromofume®; "C" Skin	25.0
Fumazone®, 1,2-dibromo-3-chloropropane, Nemagon®	1.0
methyl bromide, bromomethane	20.0
Nemagon®, 1,2-dibromo-3-chloropropane, Fumazone®	1.0
sodium methyl dithiocarbamate, Vapam®, SMDC	...
Telone®, dichloropropenes mixture	1.0
Vapam®, sodium methyl dithiocarbamate, SMDC	...
Vidden® D, 1,3-dichloropropene and 1,2-dichloropropane mixture, D-D®	1.0

Table 11. Threshold limit values of soil fumigants.

Chemicals	ppm of the substance per million parts air
Bromofume®, ethylene dibromide, EDB; "C" Skin	25.0
bromomethane, methyl bromide; "C" Skin	20.0
carbon bisulfide, carbon disulfide; Skin	20.0
chloropicrin, Larvacide®, Picfume®	0.1
D-D®, 1,3-dichloropropene and 1,2-dichloropropane mixture, Vidden® D	1.0
1,2-dibromo-3-chloropropane, Fumazone®, Nemagon®	1.0
1,3-dichloropropene and 1,2-dichloropropane mixture, D-D®, Vidden® D	1.0
dichloropropenes mixture, Telone®	1.0
EDB, ethylene dibromide, Bromofume®; "C" Skin	25.0
formaldehyde, Formalin®	5.0
Fumazone®, 1,2-dibromo-3-chloropropane, Nemagon®	1.0
hydrocyanic acid, HCN; Skin	10.0
Larvacide®, chloropicrin, Picfume®	0.1
methyl bromide, bromomethane; "C" Skin	20.0
methyl bromide-chloropicrin-propargyl bromide mixture, Trizone®	0.1
Nemagon R, 1,2-dibromo-3-chloropropane, Fumazone®	1.0
Picfume®, chloropicrin, Larvacide®	0.1
sodium methyl dithiocarbamate, SMDC, Vapam®	...
Telone®, dichloropropenes mixture	1.0
Trizone®, methyl bromide-chloropicrin-propargyl bromide mixture	0.1
Vapam®, sodium methyl dithiocarbamate, SMDC	...
Vidden® D, 1,3-dichloropropene and 1,2-dichloropropane mixture, D-D®	1.0

Table 12. Toxicity of insecticides to rainbow trout and bluegills[1]

Insecticide	Acute 24-Hour LC_{50}[2] values for: Rainbow trout µg/1	Bluegills µg/1
aldrin	14	10
Aramite®	730	480
carbaryl (Sevin®)	3,500	3,400
chlordane	22	54
DDT	8	7
demeton (Systox®)	...	195
diazinon	380	54
dichlorvos (Vapona®)	500	1,000
dicofol (Kelthane®)	110	...
dieldrin	6	14
dimethoate (Cygon®)	20,000	28,000
endrin	0.7	0.8
fenthion (Baytex®)	840	1,800
heptachlor	15	35
lindane	30	61
malathion	100	120
methoxychlor	20	31
methyl parathion	...	8,500
naled (Dibrom®)	70	220
ovex	860	870
parathion	2,000	56
Perthane®	9	21
phosphamidon (Dimecron®)	4,500	...
pyrethrins	56	78
rotenone	32	24
Strobane®	12	15
TDE	30	56
toxaphene	7.6	7.2
trichlorfon (Dylox®)	28,000	5,600
Zectran®	6,500	16,000

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[1] Data provided in 1965 by Fish-Pesticide Research Laboratory, Bureau of Sport Fisheries and Wildlife, Department of the Interior. Values are based on amount of active ingredient and were determined by the Laboratory under standardized conditions, testing rainbow trout 43-58 mm. in length at 55°F., and bluegills 45-58 mm. in length at 75°F.

[2] LC_{50} means lethal concentration that will kill 50 percent of the fish tested. µg/1 means micrograms of the toxicant per liter of water. 1 µg = 1 millionth of a gram. There are 454 grams in 1 pound.

J. Pesticide Effects and Symptoms

Although individuals may be affected differently by pesticide exposures, some of the signs and symptoms for some pesticides are quite well known. The "modes of action", ways in which pesticides affect humans, for all pesticides used today are either not-known or not completely understood, However, certain generalizations can be made based on studies conducted by medical research involving pesticide poisonings of man and animals. Some of the symptoms and signs resulting from certain pesticide poisonings are quite well known even though it may not be known exactly how the pesticide poisons the body.

1) Organic Phosphorus Pesticides

The organic phosphorus chemicals are one of the largest groups of pesticides presently being used. The group includes insecticides such as parathion, malathion, phorate, mevinphos, diazinon, TEPP and others. Toxicity values of these pesticides range from high toxicity in the case of parathion to low toxicity for malathion. The organic phosphorous pesticides are absorbed dermally, orally or through inhalation.

Their poisonous actions involve a chemical in the blood known as the cholinesterase enzyme. Since this group of pesticides affect the enzyme cholinesterase, they are sometimes referred to as "cholinesterase inhibitors" or "anti-cholinesterase compounds". When cholinesterase is unable to perform its normal body function, body nerves continue to send messages to certain muscles which make them move constantly. The muscle twitchings and weakness is referred to as tremors or fibrillations. Convulsions or violent muscle actions result if the tremors become intense.

Symptoms of organic phosphorous poisoning include: headache, giddiness, nervousness, blurred vision, dizziness, weakness, nausea, cramps, diarrhea, and chest discomfort. Signs include: sweating, pinpoint eye pupils, eyes water, excess salivation, rapid heartbeat, excessive respiratory secretions, vomiting; and the advanced stages of poisoning result in convulsions, loss of bowel control, loss of reflexes, and unconsciousness. If proper medical treatment is obtained quickly, persons in the advanced stages of poisoning and near death may be saved.

2) Chlorinated Hydrocarbon Pesticides

The chlorinated hydrocarbon pesticides are one of the older groups of organically synthesized compounds and have been used quite extensively until recent years. This group of pesticides contains insecticides such as DDT, heptachlor, BHC, endrin and others. They are known to affect the central nervous system in man, but the exact mechanism of the action in man or in animals is not known. These compounds or degradation products can be stored in fat as the result of a single large dose or repeated small dose exposures. It has been indicated in laboratory animals that the materials stored in fat appear to be largely inactive, since the total amount stored may often be greater than the lethal dose if administered at one time. The chlorinated hydrocarbon pesticides may be absorbed orally, dermally, or inhalation.

Symptoms and signs of chlorinated hydrocarbon pesticides are nausea, diarrhea, nervousness, and convulsions in some instances. Liver and kidney damage has been demonstrated in laboratory animals when administered repeated large doses.

3) Carbamate Pesticides

This group of pesticides are relatively new and includes: insecticides such as aldicarb, carbaryland carbofuran; herbicides such as cycloate and diallate, and others. The carbamates mode of action is similar to the organic phosphorous compounds. They, too, inhibit the enzyme cholinesterase; however, their action is much briefer as the carbamates are broken down in the body or metabolized quite rapidly. The carbamates are referred to as reversible inhibitors of cholinesterase. The reversal is so rapid that, unless special precautions are taken, measurements of blood cholinesterase of individuals exposed to carbamates are likely to be inaccurate and always in the direction of appearing normal.

Signs and symptoms of carbamate poisoning are similar to those caused by organic phosphorous pesticides. The carbamates can be absorbed through all portals of exposure, including oral, dermal, and respiratory.

4) Nitrophenyl Pesticides

The nitrophenyl group of pesticides in different formulations are used as fungicides, insecticides, herbicides and miticides. All of the nitrophenyl compounds can be absorbed in toxic amounts by inhalation or orally. Some formulations can be absorbed dermally.

These compounds speed up certain body processes and functions which may cause nausea, gastric distress, restlessness, sensations of heat, flushed skin, sweating, deep and rapid heartbeat, fever, cyanosis (blue body color), collapse, and coma. In cases of a single, large exposure to some of the nitrophenyls, these signs and symptoms may occur rapidly. As a general rule, death or almost complete recovery is noted within 24 to 48 hours. If the patient receives adequate medical attention and the pesticide exposure has not been severe, it is most likely he will recover completely.

In cases of chronic exposures (repeated exposures to small doses) symptoms and signs of poisoning may include fatigue, restlessness, anxiety, excessive sweating, unusual thirst and loss of weight.

5) Arsenic Pesticides

Within this group of pesticides, there are compounds that have high toxicity values such as sodium arsenite to those that have low toxicity values such as DSMA. The arsenic compounds have been used as insecticides, herbicides, defoliants, and rodenticides.

Arsenic is absorbed primarily by respiratory or oral exposure. Some small amounts can be absorbed by the skin. Body functions are slowed down as these compounds poison the cells of certain body tissues and also affect certain enzymes. Poisoned victims may have stomach and intestinal pains, diarrhea, vomiting, and a severe drop in blood pressure which may result in dizziness.

6) Phenoxy Pesticides

This is a relatively large group of pesticides which has been used many years. The group includes herbicides such as 2,4-D, 2,4,5-TP and several others. Primary means of intoxification are orally, very slight inhalation, and skin absorbtion has been noted. Practically all phenoxy compounds used are of low toxicity.

Large doses of 2,4-D given intravenously have caused symptoms and signs of muscle twitching, cessation of urinary processes, and coma. Within a period of 48 hours complete recovery was noted. As with many other chemicals, dermatitis has been noted by some individuals.

7) Botanical Pesticides

Botanical pesticides are from plant derivatives. They vary greatly in chemical structure and toxicity to man. Within this group are insecticides such as pyrethrum with low toxicity and strychnine which has high toxicity.

Pyrethrum and Allethrin - They are used against a wide variety of insect pests. Most minor symptoms in man as the result of pyrethrum exposure are reported to be skin allergies, sneezing, runny nose, and some cases of stuffiness of the nose. Some individuals are more sensitive than others.

Strychnine - The action of this pesticide is not clearly understood. It is known to act on the nervous system causing extreme nervousness in some instances. Occasionally muscles in the legs and face become stiff. Seizures have been noted, along with cold sweats and complete exhaustion.

One to ten violent attacks may occur in which case, the patient either recovers or death follows due to his inability to breath. In event of no medical treatment, most poisoning cases seldom tolerate more than five convulsions. Death will commonly occur within 3 to 5 hours after a fatal dose has been consumed. Patients surviving the first 5 or 6 hours have a good chance of recovery.

Rotenone - Very few instances of poisoning to man due to rotenone have been reported. Direct contact with rotenone will result in mild irritation of the skin and eyes in some individuals. Most of the symptoms reported have come from animal studies. In these studies, the animals exhibited numbness of the mouth, vomiting, and pains in the stomach and intestines. The inability of a test animal to coordinate his activities may result in muscle tremors with chronic convulsions following. Often breathing is very rapid, initially followed by extremely slow breathing. In cases of animal death, it is generally due to the inability to breathe. Applications of rotenone to the skin may cause irritation. Inhalation of rotenone has resulted in severe irritation inside the nose, throat, and lungs.

Nicotine - The action of nicotine poisoning is very rapid and it is extremely toxic. It is another material that affects the body's nervous system. It can be absorbed through the skin (dermally). It will cause local burns and skin irritation. Poisoning cases generally become highly stimulated and excitable which is generally followed with extreme depression. Death is very rapid in fatal cases, nearly always within 1 hour and sometimes in as little time as 5 minutes as the result of paralysis of the respiratory muscles.

8) Sodium Fluoracetate

Sodium fluoroacetate (Compound 1080) is a pesticide used primarily for rodent and predator control. The actual mechanism of its poisoning action is not clearly understood. It has a strong affect on the heart or nervous system, sometimes both in man, and skeletal muscles in some species. In poisoning cases, symptoms appear in 30 minutes to 2 hours. The first indications of poisoning are nausea and mental apprehension generally due to ventricular fibrillation and heart failure.

9) Anticoagulants

These pesticides such as warfarin, fumarin, diphacinone, and others are used primarily as rodenticides. They may have two types of effect as poisons, they may reduce the body's ability to produce blood clots or damage capillary blood movement in the body. Bleeding can occur with the slightest body damage such as severe nose bleeding and massive bruises. Severe back and abdominal pains have been noted in persons attempting suicide.

Warfarin is not significantly absorbed through the skin and it has not been known to cause poisoning through respiratory exposure.

K. Treatment of Pesticide Poisoning

It is essential that pesticide poisoning incidents be recognized immediately as prompt treatment may mean the difference between life and death.

First Aid

First aid treatment is only to provide relief for the patient until professional medical help can be obtained. It is essential that medical help be obtained as soon as possible. If two persons are at the scene of the accident, one should administer first aid and the other should call a physician. If only one person is available, before seeking medical help, be sure the person is breathing and removed from the source of exposure. The victim may need artificial respiration to restore breathing. In instances of pesticide spills or poisons on the skin, the victim should have his contaminated clothing removed and be thoroughly washed. Be sure to save the pesticide label or container for the physician. A very important precaution to be observed by individuals administering first aid procedures is to prevent the pesticide from getting on them while helping the victim. There are several specific procedures to follow when using first aid for different types of poisoning incidents.

Poison in the Eye

1) Eyes should be washed out immediately. Any delay will increase the possibility of injury.
2) The eyelids should be held open and washed with a gentle stream of clean water for at least 15 minutes or more.
3) Chemicals or drugs should not be used in the wash water as they may increase eye injury.

Poison on the Skin

1) Less injury will result if the poison is washed off the victim immediately.
2) The skin and clothing should be drenched with any source of clean water (pond, supply tank, hose, faucet, or shower).
3) Contaminated clothing should be removed very carefully.
4) The skin and hair should be cleaned thoroughly with generous amounts of soap or detergent and water.
5) Dry the victim thoroughly and wrap him with a blanket.
6) In the case of skin burns caused by chemicals, follow the same procedures; however, do not use ointments, greases, powders, or other drugs for treatment.

Inhaled Poisons (Vapors, Gases, Dusts)

1) Air supplied respirators should be used by persons going into enclosed areas to remove poisoned individuals.
2) The victim should be carried (do not allow him to walk) to fresh air immediately, preferably outside.
3) All tight clothing should be loosened.
4) If breathing is labored, irregular, or stopped, artificial respiration should be used.
5) A convulsing patient should be observed to watch his breathing and protect him from falling and causing other bodily injury. The victim's chin should be kept up to allow free passage of air.
6) The patient should be kept as quiet as possible.
7) Chilling should be prevented by wrapping the victim in a blanket. Use care to prevent overheating.

Poisoning by the Mouth (Orally or Ingestion)

A decision must be made by the person administering first aid as to whether or not the victim should be induced to vomit. This decision must be made promptly and accurately. In most instances it is desirable to get rid of the swallowed poison immediately. There are some instances when vomiting should never be induced:

1) Do not induce vomiting if the patient is in a coma, unconscious, or in convulsion.
2) Do not induce vomiting if the patient has swallowed a corrosive poison such as a strong acid or alkaline product; or exhibits symptoms of severe pain or burning sensations in the mouth and throat. Corrosive poisons will burn the mouth and throat areas as severely when coming up as when going down.
3) Do not induce vomiting if the victim has ingested petroleum products such as kerosene, diesel fuel, gasoline, lighter fluid, or concentrated emulsifiable formulations of pesticides. These materials will cause mouth and throat burns similar to corrosive poisons.

Corrosive Poisons

It is necessary to dilute and neutralize the poison as quickly as possible and take the victim to the hospital.

For treatment of acid and alkali poisoning, give the patient water or preferably milk, 1 to 2 cups for victims under 5 years of age and up to 1 quart for patients over 5 years. Milk is better than water as it has a diluting and neutralizing action.

For treatment of acid poisoning only, give the victim milk of magnesia (1 tablespoon to 1 cup of water), baking soda or chalk in water.

For treatment of alkali poisoning only, give the patient lemon juice or vinegar.

Non-Corrosive Poisons

Vomiting can be induced in victims who have ingested non-corrosive poisons. Time should not be wasted inducing vomiting if the patient can receive immediate medical attentions where drugs and stomach pumps are available. The patient should be given a large amount of milk or water as specified under treatment of corrosive poisons. The large amount of liquid is needed to dilute the poison and provide enough liquid substance for vomiting.

Vomiting can be induced by putting your finger or the handle end of a spoon at the back of the victim's throat. There are emetics that can be used to induce vomiting, if available, such as 2 tablespoons of salt in a glass of warm water.

When the retching or vomiting begins, the patient should be placed face down with his head lowered which will prevent vomit from entering the lungs and causing further damage.

L. Antidotes for Pesticide Poisoning

Several antidotes should be given or prescribed by a qualified physician. They can be extremely dangerous if misused and should never be used as a prophylatic measure to prevent pesticide poisoning. An antidote is a remedy used to counteract the effects of a poison or prevent or relieve poisoning.

The following is a brief discussion of the most common antidotes for external and internal use.

External Antidotes

Clean water can be used to dilute and wash away poisons. It is recommended to be used for poison in eyes or on skin and other tissues. A ready supply of clean water should be available for emergency use when pesticides are being used.

Soap and water can be used to dilute and wash away poisons. It is recommended for poison on the skin, hair, under fingernails, and other external areas not irritated by soap such as eyes. Soap along with previously mentioned water should be available when handling pesticides.

In an emergency use any water such as irrigation canals, lakes, ponds, water troughs, or any other type as any source of water is better than none.

Internal Antidotes

Clear water may be used as a diluent.

Salt water may be used as a diluent and agent to induce vomiting.

Milk may be used as a diluent and helps neutralize acid or alkali poisons.

Milk of magnesia may be used to neutralize acid poison. It can be found in home medicine chests and is readily obtainable from druggists.

Universal antidote can be obtained from druggists. It is a mixture of two parts activated charcoal, one part magnesium oxide, and one part tannic acid. It is given to the victim as 1/2 ounce in 1/2 glass of warm water to absorb or neutralize poisons except in the case of corrosive poisons.

Homemade universal antidote can be made with 4 tablespoons of crumbled, burnt black toast, 2 tablespoons strong tea (any type tea) and 2 tablespoons milk of magnesia.

Activated charcoal can be obtained from druggists. It is mixed with water to form a thick soup and it will absorb many poisons.

Syrup of ipecac is used to induce or promote vomiting. It should be used only as directed on the label or by a physician. It can be poisonous if improperly used.

Vitamin K is used by physicians only to counteract anticoagulant poisonings.

BAL (dimercaprol) is used by physicians only and it is specific for arsenic poisoning.

Atropine sulfate is used to counteract effects of cholinesterase inhibitor pesticides and should only be administered under a physician's supervision.

Protopam chloride (2-PAM) can be used to counteract effects of many organo phosphorous pesticides. It also should only be used by physicians. It should not be used when poisoning is caused by carbamates.

Antidotes for Specific Classes of Pesticides

These are specific antidotes recommended to counteract or alleviate their poisoning effect of some classes of pesticides such as: anticoagulants; arsenicals; bromides and carboxides; carbamates; chlorinated hydrocarbons; chlorophenoxies; ureas and miscellaneous herbicides; cyanides; dinitrophenols; fluoroacetates; and organo phosphates.

Anticoagulants - Vitamins have been used successfully for treatments.

1) Vitamin K administered by mouth, intravenously or intramuscularly.
2) Vitamin C is a useful adjunct.

Arsenicals - There is a specific antidote for poisoning caused by arsenic compounds.

1) BAL (dimercaprol) administered intramuscularly.

Bromides and Carboxides - Treatment with antidote is as follows.

1) Barbituates to ease convulsions.
2) BAL (dimercaprol) may be administered before symptoms appear.

Carbamates - The following antidote has been used successfully to treat victims of carbamate poisoning.

1) Atropine sulfate is recommended for carbamate poisoning.
2) Do not use protopam chloride (2-PAM) to treat carbamate poisoning.

Chlorinated Hydrocarbons - Antidotes prescribed for chlorinated hydrocarbon poisoning are as follows.

1) Calcium gluconate administered intravenously.
2) Barbituates to ease convulsions and restlessness.
3) Never use epinephrine (adrenalin).

Chlorophenoxies, Ureas, and Miscellaneous Herbicides - No recommended antidotes, maintain life supports (body temperature, breathing, and other body processes).

Cyanides - For poisoning with cyanide pesticides, the following antidotes have been used.

1) Amyl nitrate through inhalation.
2) Sodium nitrite administered intravenously.
3) Sodium thiosulfate given intravenously.

Dinitrophenols - Treatment of dinitrophenol poisoning is as follows.

1) Maintain life supports.
2) Sodium methyl thiomacil will reduce basal metabolism rates which increase due to poisoning.
3) Never use atropine sulfate as an antidote for poisoning caused by dinitrophenol pesticides.

Fluoroacetates - Treatment for poisoning is primarily symptomatic.

1) Monacetin (glycerol monoacetate) administered intravenously.
2) Oral doses of magnesium sulfate may be useful.

Organo Phosphates - There are many pesticides in this group and the following antidotes have been successfully used to treat poisoning.

1) Atropine sulfate will counteract the effects of organo phosphorous compounds. Injections by a physician should be repeated as symptoms recur.
2) Protopam chloride (2-PAM) can be injected to counteract organo phosphorous poisoning. It is administered intravenously.
3) Never give morphine, theophylline, or barbituates.

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Additional information can be obtained in regard to poison treatment by contacting the following:

Poison Control Centers	Phone	In Charge
Ohio - National Poison Control Center	513/961-4300	--
Casper - Poison Control Center Natrona County Hospital 1233 East 2nd St., 82601	307/235-1311 Ext. 131	D. L. Becker, M.D. Joy J. Smith, R.Ph.
Cheyenne - Poison Control Center Laramie County Memorial Hospital 23rd & House Sts., 82001	307/634-3341 Ext. 238	Laurence J. Cohen, M.D. Rachel Garlick, R.N.

SECTION V

Storage of Pesticides

Household or home garden pesticides should be stored in a cabinet always in the original container and only with a legible label. The cabinet should be located outside of the living quarters, preferably in an area not subjected to temperature extremes (especially high temperatures) as many formulations for homeowner's use are aerosal bomb types which are subject to rupture under extremely high temperatures. The storage area should be located away from food, feed, or clothing, be clearly identified and locked to keep children and pets from coming into contact with pesticides.

Pesticides intended for agriculture, vector control, and industrial uses require storage under more rigid conditions due to greater volumes of generally more toxic materials. Proper storage of pesticides will protect the health and well being of people, help protect against environmental contamination, and protect the chemical's shelf life.

All pesticide containers should be kept tightly closed and air vents to facilitate pouring should be plugged. When chemicals are subjected to high temperatures, they may expand causing drumheads to bulge and leak. High temperatures have been noted to reduce the effectiveness of emulsifiers, speed up container erosion, and, in some instances, cause the pesticide to deteriorate. Low temperatures (below 32° F) also cause problems in pesticide storage. Some compounds will freeze and upon expansion rupture metal or glass containers. Other compounds under low temperatures may settle or crystallize out of solution. Liquid containers should be stored on pallets to avoid rusting of metal containers.

Dusts and powders will tend to cake when wet or subjected to extremely high humidity. They too should be stored on pallets to prevent moisture absorption.

The following suggestions should be observed when storing pesticides:

1) Storage in a separate building is preferable; however, an isolated storage room can be used in some instances.

2) The storage area should be well ventilated and have a source of heat for pesticides stored in areas noted for cold temperatures.

3) Always store pesticides in the original container with intact legible labels.

4) The storage area should be located away from food, feed or seed.

5) Sheds, buildings or cabinets used for pesticide storage should be clearly identified and kept under lock and key.

6) Containers should be checked periodically for corrosion, leaks, breaks, or tears so that faulty containers may be disposed of or replaced before they constitute a hazard.

7) When large amounts of pesticides are being stored, records should be kept on the kind and quantity.

8) Empty pesticide containers should be kept in the storage area until properly disposed of.

Storage life of various pesticides is considerably different. Some pesticides belonging to the chlorinated hydrocarbon group can be stored for a number of years with little or no chemical change. Other pesticides such as organic phosphorous compounds tend to have a rather short storage life. Climatic conditions such as high temperatures, high humidity, and sunlight may cause a chemical breakdown or degradation of certain pesticides, especially when they are formulated as wettable powders or dusts. Compounds that are subject to degradation will have labels that provide instructions to prevent it.

Unsealed packages of powdered pesticides should not generally be kept longer than one year. Some pesticides in liquid form in airtight containers may retain their effectiveness for several years if kept sealed.

Sometimes pesticides have been stored for long periods and doubt exists as to their effectiveness. In this case, try small amounts of it according to label directions. If the treatment is satisfactory, use it up promptly.

Pesticide fire and explosion hazards are based on the flash point of a particular product. A pesticide with a low flash point (140° F or less) is dangerous in storage. Pesticide formulations having flash points at or below 20° F must have on the label "Danger - Extremely Flammable! Keep away from sparks and heated surfaces." Those products with flash points above 20° F, but not over 80° F, must be labeled with the statement, "Warning - Flammable! Keep away from heat and open flame." Pesticides with a flash point above 80° F, but not exceeding 150° F must bear the statement, "Do not use or store near heat or open flame."

When pesticides are purchased, check the label for these warnings and make sure that they are used and stored according to the directions to prevent the hazard of fires and explosions. Pesticides containing oils or aromatic petroleum distillates are the ones most likely to have such warnings on the label. Certain dry formulations also present fire and explosion hazards. Sodium chlorate is well known for its potential to ignite when in contact with organic matter, sulfur, sulfides, phosphorous, powdered metals, strong acids or ammonium salts; therefore, when a container of sodium chlorate is opened, the entire contents should be used. A container partially full should never be stored. Certain dusts or powders, particularly those that are very fine such as sulfur, may ignite as easily as gases or vapors; and do it so rapidly that they seem to be explosive.

Fire hazards may be reduced by the following suggestions:

1) Keep the storage area locked at all times when not in actual use to prevent fire accidentally set by man.

2) Do not store glass containers in sunlight where they might concentrate heat rays and start fires.

3) Store combustible materials away from steam lines and heating devices.

4) Sheetrock or other fireproof materials should be used to line the storage area.

5) Large storage areas should have fire sprinkler systems.

6) Be familiar with fire alarms, fire exits, and fire fighting equipment.

7) Storage areas should be located as far as possible away from other buildings and populated areas.

8) The fire department and other officials should be informed of pesticide storage areas - the nature, quantity, and hazards of the stored materials - in the event of a fire.

Firemen should, along with proper protective clothing and respirators, consider the following suggestions:

1) Stay upwind of the fire.

2) If the fire cannot be fought successfully from a position where sufficient air dilution is available, people should be moved away and the property be allowed to burn.

3) The fireman's sense of smell may serve as a warning device to detect poisonous fumes.

4) Hot pools of pesticides may liberate large amounts of pesticide as vapors in extremely hazardous concentrations even though the flame might be extinguished.

5) Firemen should avoid using heavy hose streams if possible, as the force of the stream spreads contamination and will

cause dusts to become airborne. Airborne dusts may present an explosion hazard as well as a toxic hazard.

6) Firemen should be aware that overheated containers may erupt at any time and should try to keep a safe distance from the fire. If drums are not leaking, they may be sprayed to prevent them from overheating.

7) The runoff of water from a fire involving pesticides should be diked to prevent it from entering sewers or streams.

8) Firemen should wash and change clothing immediately after the fire.

9) All clothing, boots and other equipment should be thoroughly washed.

SECTION VI

Disposal of Pesticide Waste and Containers

Proper pesticide waste and container disposal is important. It is stated that a pesticide user's responsibility for safe use does not end until the unused chemicals and empty containers are disposed of. Improper disposal of pesticide wastes and containers over the past years has resulted in a number of incidents involving animal poisonings and environmental contamination.

Unfortunately, there are no easy or perfect means to dispose of excess pesticides and empty containers. Pesticide wastes range in type from materials left after a pesticide fire or spillage to excess spray mixture left over from an application. Pesticide containers vary from hard-to-dispose 55 gallon drums to aerosol cans or to paper bags. Supposedly, empty pesticide containers are never really empty as several ounces of pesticides can generally be found in discarded containers. Many times the concentrations of the active ingredient in liquid formulations will tend to increase in toxicity as the solvents evaporate from the discarded container.

There are several proposed methods of pesticide waste and container disposal that are feasible under certain conditions. It is the user's responsibility to select the most feasible method. Every possible alternative should be considered in relation to the problem giving consideration to the environment.

The choice or selection of the disposal method will depend on several factors such as - pesticide type; container type; facilities available for disposal; the nearness to communities, streams and crops; and any other geological or environmental considerations. The failure to consider any of these factors may result in more complex problems in the future.

Surplus pesticide disposal can be kept at a minimum with some advanced planning. The safest means of disposal is to use the pesticide exactly as the label directs for the purpose for which it is intended. To do so, requires some consideration as follows:

1) Plan carefully to determine the kinds and amounts needed and purchase accordingly.

2) Study the label, follow directions and prepare only as much pesticide as needed for the job.

3) Plan to use all of the spray, dust, or granule prepared for the application.

4) All container tops, lids, or bungs should be securely closed when pesticides are not being used.

5) All pesticide containers, including empty ones, should be kept in storage until used or disposed of properly.

6) Be sure that all the pesticide is drained or removed from a container before disposal.

7) Rinse the empty container thoroughly with water when using liquids and add the rinse to the spray solution. See page I-86

The National Agricultural Chemical Association has suggested a procedure to use when rinsing containers prior to disposal that reduces their hazard potential. The procedure involves the following steps:

1) When the container is being emptied allow it to drain in a vertical position for 30 seconds.

2) Best results are obtained when the container is rinsed three times, allowing 30 seconds for draining after each rinse.

3) Water or other diluting materials being used in the spray program can be used to rinse the container as follows: Use 1 quart for each rinse of a 1 gallon can or jug; a gallon for each 5 gallon can; and 5 gallons for either 30 or 55 gallon drums.

4) Each rinse should be drained into the spray tank before filling it to the desired level.

Unwanted pesticides are generally handled by one of two means, either recycling or disposal.

Recycling of pesticides requires returning them to the manufacturer. Many times this is not feasible with some pesticides and generally it is expensive. It generally requires relatively large amounts of properly identified pesticides for the recycling method to be feasible.

Disposal of surplus pesticides is the final outcome when they cannot be used or recycled. Warning - Never pour pesticides down the drain or flush. Present methods of pesticide disposal include burial, incineration, degradation, and in some instances permanent storage.

Local burial sites that are individually owned or a community project are probably the most common method of pesticide disposal. There are probably more environmentally safe disposal methods, but under present circumstances burial may be the only feasible means of disposal. Sites for burial of pesticides should be selected keeping the following suggestions in mind:

1) Select a site that will never be used for domestic crop production, water supplies, or building site purposes.

EMPTY *and* RINSE*

Pesticide Containers thoroughly

Laboratory tests show that even a good effort to empty a drum leaves about 6 ounces of pesticide in a 5-gallon container and 32 ounces in a 55-gallon drum.

Your in-the-can loss with pesticides costing $20 and $30 per gallon is shown below.

Empty to save money

AMOUNT OF RESIDUE	$ LOSS AT:	
	$20/GAL.	$30/Gal.
6½ OZ.	$1.00	$1.50
32 OZ.	$5.00	$7.50

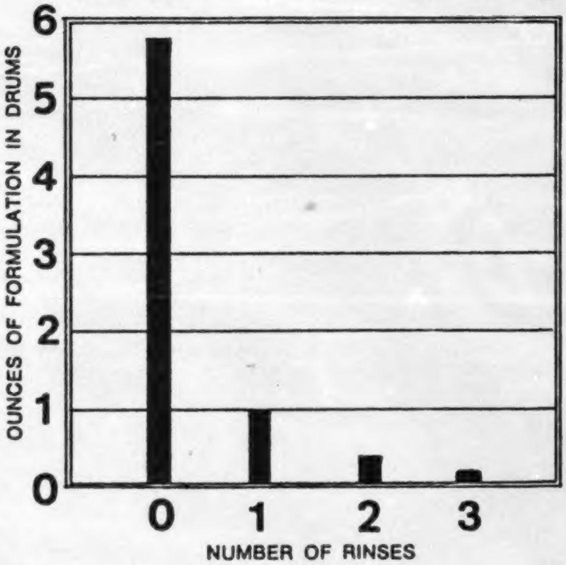
AN EASY WAY TO CUT COSTS!

"Empty" Containers thoroughly

Rinse with several quarts of water —once, twice, or THREE times and pour the rinse water into a sprayer. You save money with each of the rinses.

The value of rinsing a 5-gallon "empty" container is illustrated below.

Rinse to save money



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* From Washington State Pest Control Handbook

2) The area should be on high ground, flat, or gently rolling, away from water drainages and sources.

3) The site should have deep soil at least 8 to 10 ft from the surface to the lower level of downward leaching or percolation of water before running into bedrock or hard-pan where lateral water movement takes place.

4) The burial disposal area should be fenced and posted with easily identified and maintained signs.

Sanitary landfill burial sites are generally public operated and they must meet all the requirements of local burial sites plus the following:

1) The site selected for its safe disposal characteristics should be as convenient as possible.

2) The landfill operation must be in compliance with local and state laws.

3) A qualified supervisor should be in charge to conduct a sound management program.

4) The disposal site should be open at regular intervals with times posted and announced in local advertisements.

5) Records should be kept as to the types of pesticides placed in the disposal site.

6) The landfill site should be selected and designed for burying, burning, and liquid waste disposal.

7) Pesticide waste should be covered the same day of disposal.

8) Sanitary landfill employees should use proper protective clothing when disposing of high toxicity materials.

Incineration of pesticides is probably the most positive approach to disposal. Research has shown that temperatures of 1,000° C will degrade 99% of most pesticides. The limiting factor, however, in this means is very expensive; and incinerators available in most areas are not designed to do an adequate job. Any incinerator used must be designed to remove any hazardous emissions that would be released into the atmosphere.

Degradation of pesticides for disposal would be an ideal means of pesticide detoxification. Several methods might be used including the following:

1) Physical degradation by providing a means of spreading the unwanted pesticide over large areas, where minimum hazard to man and wildlife would be expected, at recommended rates.

2) Biological degradation could be used quite effectively for those pesticides that are effectively degraded by soil organisms and by plants.

3) Chemical degradation may be accomplished by ion exchange, coagulation, oxidizing, and absorption.

Storage disposal has been considered for some pesticides such as mercury and other heavy metals that are extremely long lived. This would entail placing materials in containers that could be permanently sealed and never develop leaks. The primary disadvantage of using storage as a means of pesticide disposal would be finding an area large enough and suitable for indefinite storage. From the standpoint of practicability this method will probably never be used for pesticide disposal.

Pesticide Container Disposal

Many of the same procedures for disposal of waste pesticides are applicable to container disposal. There are several safety procedures to observe when disposing of high toxicity pesticide containers. These procedures are similar to those discussed under pesticide safety with some additional suggestions as follows:

1) Assume all empty pesticide containers still contain sufficient quantities of toxic material to cause detrimental effects.

2) Workers in disposal areas should be aware of hazard to themselves and to others and be provided with protective safety equipment.

3) Workers should know what to do in case of an emergency. Under no circumstances should empty containers be abandoned, allowed to accumulate in fields or any area accessible to children, unauthorized persons, or animals. Empty containers should be kept in storage areas that can be locked.

Container types are primarily of two kinds, combustible and noncombustible. Combustible containers are those that can be destroyed by fire. They are paper bags, fiber drums, cardboard boxes, cloth bags, burlap bags, fiber boxes, certain plastic containers, and wooden boxes. Noncombustible containers are those manufactured from glass, metal, and plastic.

Combustible container disposal can be accomplished by burning or burial. Some combustible containers can be burned unless the label warns against it or there are restrictions in the area against burning. Burning sites may be commercial incinerators, supervised landfills, or, in some areas, an open fire at the site of use if permitted by local regulations.

There are certain combustible containers that should not be burned such as those that are used for certain herbicides, high volatile chemicals, and chemicals that have high toxicity in the volatile phase.

Containers that have been used for compounds that might explode such as sodium chlorate should not be burned. Also, aerosol containers should never be burned.

Combustible containers that cannot be burned should be buried in a manner as discussed for pesticide waste disposal.

Noncombustible containers consist of small type containers that should never be reused and larger types that are sometimes recycled for other uses.

Small noncombustible containers can be disposed of by observing the following procedures:

1) Rinse the container with water as previously discussed under surplus pesticide disposal or use a decontaminating solution.

2) The rinse should be buried at the disposal site.

3) All small containers, except for aerosol type, should be destroyed. Glass containers should be broken, metal and plastic containers should be crushed or punctured to prevent reuse and reduce bulk in disposal site. Containers should not be broken or destroyed until delivered to the disposal site.

Large noncombustible containers are generally disposed of using one of the following procedures:

1) Recycling of some large containers is possible if facilities are available in the area. Some manufacturers will accept empty containers for reuse.

2) Burial of large containers is satisfactory if the same procedures as discussed for small noncombustible containers are followed.

3) Scrap metal - Metal drums can frequently be disposed of as scrap metal. If disposed of as scrap metal, it is often necessary to decontaminate, flatten, or compress barrels for shipping.

Decontamination solutions can be made using the following proportions:

Container Size	Water	Detergent	*or*	Caustic Soda
5 gal	2 qts	2 tbsp		1/2 cup
30 gal	3 gal	1/2 cup		1 lb
55 gal	5 gal	1 cup		2 lb

SECTION VII

Record Keeping

Record keeping plays an important role in the success of any agricultural enterprise. In many instances, the history of pesticides on land is as important as the cropping history. Previous pesticide use on land may dictate the crops that can be planted the year following treatment. Many times potential land buyers will ask present owners for pesticide application history prior to making the purchase. Accurate records of pesticide use will help the producer to:

1) Determine pesticide amounts and purchase only those needed.
2) Conduct improved pest control programs and prevent pesticide misuse.
3) Decide if results obtained were comparable with results from previous pesticide applications.
4) Detect errors, if any were made, and provide a means of solving errors.
5) Provide a means of establishing proper use should any question of excess residues appear in the product to be marketed.
6) Establish that recommended procedures for pesticide application were followed should problems arise and indemnity payments are involved.
7) Eliminate guessing in what crop should be planted following the previous year's pesticide application.

Information to keep in a crop pesticide record should include the following:

1) Crop variety and stage of growth to be treated.
2) Pesticide common or trade name.
3) Acres treated.
4) Planting and treatment dates.
5) Primary pest species controlled.
6) Method of application -- ground rig or aerial application.

7) Type of pesticide formulation used and the pounds per gallon or percent active ingredient.

8) The amount of pesticide mixed per gallon or 100 gallons of diluent.

9) Total volume or gallons of mixed spray per acre, or in the case of dry materials the pounds of granule or dust applied on an acre basis.

10) The type of application used.

11) Soil data consisting of moisture, texture and condition at treatment time.

12) The method, the amount and the dates of irrigation.

13) A notation regarding temperature, wind and rainfall can often explain the action of a pesticide.

14) Some general remarks may consist of results obtained from the treatment, problems encountered during the operation, cost of the treatment, days required to wait between treatment and harvest, in some cases worker reentry intervals and any other general remarks.

Similar applicable data should be included in keeping livestock pesticide records. Pesticide record data can be kept in a small notebook. Everything should be recorded, do not leave it to memory. When convenient, data from a notebook can be transferred to a permanent pesticide record sheet that is filed.

CROP PESTICIDE RECORD

Year______________

Crop________________________________ Grower's Name__________________________

Variety_____________________________ Field Ident.___________________________

Growth Stage________________________ Acres_________________________________

Primary pest or pests to be controlled______________________________________

Pesticide's common name or trade name_______________________________________

____

Planting date_______________________ Treatment Date__________________________

Method of application (ground, air)____

Formulation (liquid, wetable powder, dust or granule)_______________________

Active ingredient (lb per gallon or percent)________________________________

Amount of pesticide per gallon or 100 gallons of dilution___________________

Gallons of mixed spray per acre____

Pounds of granules or dusts per acre____

Type of application: preplant ( ), preemergence ( ), postemergence ( ),
incorporated to depth ( )

Soil moisture: dry ( ), intermediate ( ), wet ( )

Method of irrigation____

Amount of irrigation and dates____

Soil texture: sandy loam ( ), loam ( ), clay loam ( ), heavy clay ( ),
organic ( )

Soil conditions: no clods ( ), small clods ( ), large clods ( ),
organic matter (high) or (low)

Weather conditions____

Remarks (results, problems, costs, harvesting intervals, reentry intervals, etc.)____

____

____

____

Use reverse side for field sketch if desired.

USE SPACE BELOW FOR SKETCH TO DESCRIBE TREATED AREA, IF NECESSARY.

LIVESTOCK PESTICIDE RECORD

Year_______________

Animal Species______________________ Producer's Name____________________

Market Class________________________ Age____________________________

Primary pest or pests to be controlled_____________________________________

Pesticide's common or trade name____

Formulation (dust, EC, WP, drench, dip)___________________________________

Rate of application____

Amount of pesticide per gallon of dilution________________________________

Treatment date(s)____

Date of last treatment____

Earliest date that meat, milk or eggs can be marketed following last treatment____

Estimated treatment costs____

Weather conditions____

Remarks (results, animal peculiarities, problems, etc.)___________________

____

____

____

____

SECTION VIII

Glossary of Pesticide Terms

Abscission - The formation of a layer of cells which cause the fruit, leaf, or stem to fall off the plant.

Absorption - Penetration of a substance from the surface to below the surface.

Acaricide (Miticide) - A compound used to control mites or ticks.

Acid equivalent - The theoretical yield of parent acid from an active ingredient.

Activator - Materials used in a pesticide formulation to increase the effectiveness of the toxic materials toward the target pest.

Active ingredient - That part of a chemical compound directly responsible for the control of the specific pest.

Acute toxicity - The amount of a substance, as a single dose to cause poisoning in a test animal.

Acute Oral LD_{50} - It is the dosage required to kill 50% of the test animals when given a single oral dose in toxicity studies. The dose is expressed by the weight of the chemical per unit of body weight such as milligrams of toxicant per kilogram of body weight of the test animal.

Adhesive - A substance that will cause a spray material to stick to the sprayed surface, often referred to as a sticking agent.

Adjuvants - Any component of a formulation such as wetting or spreading agents, stickers, penetrants, emulsifiers, etc. which modifies the mixture beneficially.

Adsorption - Adherance of a substance to a surface.

Aerobic - Living or functioning in air or oxygen.

Aerosol - Colloidal suspension of solids or liquids in air.

Agitate - Keeping a mixture stirred up.

Algae - Nonvascular chlorophyll containing plants, usually aquatic.

Algicide - Substances which kill or inhibit the growth of algae.

Alkaloid - Nitrogenous toxic materials appearing in some plants which are used in preparing the botanical - derived pesticides.

Aliphatic - Chemically, those compounds that possess open-chain molecular structures. Generally are considered less toxic to plants than aromatic compounds.

Anaerobic - Living or functioning in the absence of air or free oxygen.

Analog - A compound that is very similar in both structure and formula to another one.

Anionic surfactant - A surface - active additive to a pesticide having a negative surface charge. Most wetting agents and detergents and some emulsifiers are anionic.

Annual - A plant that completes its life cycle in one year.

Antagonism - The phenomenon which results in a depression of compound activity when two or more are in close proximity or mixed together.

Antibiotics - Chemicals produced by microorganisms which kill or inhibit growth of other competing microorganisms.

Antidote - A practical immediate treatment including first aid in case of poisoning.

Anticoagulant - A substance which prevents normal blood-clotting.

Antioxidant - A material capable of chemically protecting other substances against oxidation or spoilage.

Aphicide - A compound used to control aphids or plant lice.

Aquatic plants - A plant that grows in water. There are three types: submergent, grow beneath the surface; emergent, root below the surface but plant extends above the water; and floating.

Aqueous - As in aqueous solution indicating the presence of water in a solution.

Aromatics - Oil or oil-like materials which kill plant and animal tissue similar to burning. Chemically, a compound having a closed ring structure.

Arsenicals - A pesticide group composed principally of arsenate and arsenite compounds.

Aseptic - Free of disease causing organisms.

Attractant - Any substance which lures insects, rodents or other pests to selected locations where they may then be captured or destroyed.

Avicide - Compounds used to control bird populations.

Bacteria - Microscopic one-celled non-chlorophyll containing plants.

Bactericides - Chemicals which kill or inhibit growth of bacteria many times referred to as disinfectants.

Bait - An edible material that is attractive to pests which normally contains a pesticide.

Band or row application - An application to a continuous restricted area such as in, on, or along a crop row, rather than over the entire field area.

Band treatment - A treated strip extending a few inches on each side of the crop row.

Basal treatment - A treatment applied to the stems or trunks of plants at and just above the ground line.

Bed - A narrow flat-topped ridge on which crops are gorwn with a furrow on each side for irrigation or water drainage.

Biennial - A plant that completes its life cycle in two years. The first year the seed germinates and the plant produces leaves, roots and stores food which is frequently referred to as the rosette stage. The second year it flowers, produces fruit and seed.

Bioactivity - Pertains to the property of affecting life.

Bioassay - The qualitative or quantitative determination of a substance by response measurements of treated living organisms as compared to measurements on untreated, check or standard living organisms.

Biological control - Controlling a pest by its natural enemies that may already occur in the area or be introduced.

Botanical name - A scientific name made up of the genus and species.

Botanical insecticide - Natural occurring compounds which are derived from plants and are toxic to insects.

Brand name - The name, number, trade-mark or designation applied to an economic poison of any particular description by the manufacturer, distributor, importer or render.

Broadcast application - An application of pesticide over the entire area or field rather than only to rows, beds, middle or individual plants.

Broadleaf plants - Botanically classified as dicotyledons. Plants have two cotyledon leaves in the seedling stage; true leaves are broad and have net-like or reticulate veins.

Brood - The offspring, all of approximately the same age, rising from a single species of organism.

Brush control - Control of woody plants.

Bud spray - A pesticide application to trees any time between the time the first color appears in the ends until the buds begin to open.

Carbamate - A compound derived from carbamic acid such as carbaryl and eptam.

Carcinogen - A substance capable of producing cancer.

Carcinogenic - A term used to describe the cancer producing property of a substance.

Carrier - The liquid or solid material added to the active ingredient to facilitate its preparation, storage, shipment or field application.

Catalyst - A substance that speeds up the rate of a chemical reaction but is not itself used up on the reaction.

Causal organism - The organism that produces a given disease.

c.f.s. - Cubic feet per second.

Chemosterilant - A compound capable of producing reproductive sterilization.

Chlorinated hydrocarbon - A compound containing chlorine, hydrogen and carbon.

Chlorosis - The yellowing of normal green plant tissue because of partial failure of the chlorophyll to develop.

Cholinesterase (Acetylcholinesterase) - An enzyme (organic catalyst) capable of influencing the rate of hydrolysis of acetylcholine thereby limiting the activity of the nerve impulses.

Chronic toxicity - Results produced in test animals exposed for long periods to chemicals.

Combustible - Will burn when near an open flame or spark.

Compatibility - Refers to chemical compounds that can be mixed together without detrimentally affecting the performance of either.

Concentrate - Opposite of dilute. A liquid or dry formulation containing a high percentage of toxicant to save shipping and storage charges and yet be of convenient strength and composition for dilution.

Concentration - Refers to the amount of active ingredient or acid equivalent in a given weight or volume of a mixture. Recommendations and specifications for concentrations of pesticides are frequently given as pounds per unit volume of mixture.

Contact pesticide - One that kills plant tissue which it comes into contact with or causes an insect's death when it touches its external parts.

Contaminate - To alter or render a material unfit for a specified use, by allowing the pesticide to come into contact with it.

Control - May not mean eradication, but reduction of the pest problem to a point where it does not cause economic damage.

Crook stage - Plant stage of growth as it emerges from the soil before the stem becomes erect.

Crown - The point where stem and root join in a seed plant.

Cuticle - Waxy, fatty material that covers plant surfaces such as leaves.

Cut-surface application - Treatments applied to frills or girdles that have been made through the bark into the wood of a tree.

Cyclodienes - Compounds with a ring structure.

Deciduous plants - Those plants which are perennial in habit but lose their leaves during winter.

Deflocculating agent - A material added to a suspension to prevent particles from clumping together and settling out of spray tanks.

Defoliant - A compound used to cause leaves or foliage to drop from the plant.

Degradation - The process by which a chemical is decomposed or broken down into less complex compound or element.

Deposit - The amount of pesticide laid down immediately following application.

Dermal toxicity - Measures the amount of a pesticide or poisonous material that can be absorbed through the skin of animals to produce toxic symptoms.

Desiccant - A chemical used as a harvest aid to dry up plant leaves and forage.

Detergent - Primarily used as a cleansing agent. It is often used as a wetting agent to reduce surface tension of spray droplets.

Dicot (Dicotyledon) - A plant that has two seed leaves or cotyledons; broadleaf plants.

Diluent - Any liquid or solid material used to dilute or carry an active ingredient.

Dinitros - A common designation for dinitro-phenol contact pesticides.

Directed application - Applying a pesticide to a restricted area such as rows, beds or at the base of plants.

Disease - A condition in which any part of a living organism is abnormal as the result of an infectious or non-infectious agent.

Disinfectant - Similar to bactericide. Chemicals which kill or inhibit growth of bacteria.

Dispersing agent - A material that reduces the cohesive forces between similar particles.

Dissolve - Refers to getting solids into solutions.

Dormant - Period of time in which seeds and other plant parts do not grow due to natural causes.

Dormant spray - Pesticide application during the period after leaf fall and before buds break.

Dose (Rate) - The terms are the same; however rate is preferred. They refer to the amount of active ingredient applied to a unit area regardless of percentage of chemical in the carrier.

Drift - The movement of air-borne pesticide particles by air motion or wind away from the intended target area.

Dusts - Consist of the pesticide and some inert carrier such as clays, talc, attapulgites, walnut shell, calcium carbonate and others as carriers or diluents to facilitate application.

Ecology - The science concerned with the interrelationships of organisms and their environments.

Emergence - The act by germinating seedlings of breaking through the soil surface.

Emetic - A material used to cause vomiting to rid stomachs of poisonous substances.

Emulsifiable concentrate - A liquid formulation in which the chemical is dissolved in one or more water insoluble solvents such as oil or benzene and an emulsifying agent is added. The resulting mixture can be sprayed using water or oil as a diluent.

Emulsifier - A surface active material that facilitates the suspension of one liquid in another.

Emulsion - The suspension of one liquid as minute globules in another liquid such as oil dispersed in water.

Endemic - A low incidence of disease, but more or less constant in a given population.

Enzyme - A natural occurring substance which regulates the rate of reaction but remains chemically unchanged itself.

Epidemic - A sudden widespread increase of disease incidences.

Epinasty - Twisting or curling of leaves and stems caused by uneven cell growth. Characteristic plant symptoms when treated with phenoxy type herbicides and other growth regulators.

Eradication - Complete elimination of the pest problem from a designated area.

Ester - A compound formed by reaction of an acid and an alcohol accompanied by the loss of water formed during the reaction.

Filler - A diluent in the powdered form.

Flag stage - Stage of growth in cereals and other grasses at which the sheath and leaf have been produced from which the head will emerge.

Foliar application - Applications of the pesticide to plant foliage.

Formulation - A mixture containing the active pesticide, the carrier, diluents and other additives required to make the material ready for application.

Fortified - Pesticide properties of one product may be enhanced by fortifying or adding another.

Fumigant - A pesticidal compound that controls organisms when it forms a gas or vapor form.

Fungicide - A pesticide used to destroy or inhibit fungi growth.

Fungus - All non-chlorophyll bearing lower plants such as rusts, smuts, mildews, and molds. (Plural form Fungi).

Germicide - A substance used to kill micro-organisms.

g.p.m. - Gallons per minute.

Granules - Pesticide formulation in which the active ingredient is impregnated on small particles of carrier such as clay or ground-up corncobs.

Grass - Botanically, any plant of the Gramineae family. Grasses are characterized by narrow leaves with parallel veins; by leaves composed of blade, sheath and ligule; by jointed stems and fibrous roots; and by inconspicuous flowers usually arranged in spikelets.

Growth stages of cereals - Tillering stage: When a plant produces additional shoots from a single crown; Jointing stage: When the internodes of the stem are elongating and the nodes can be felt by pinching the stem; and Boot stage: When the seed head of the plant is about to emerge from the sheath.

Growth regulator - Chemical substance that when applied in small amounts will alter the growth and behavior of a plant.

Grub - The larval stage of some beetles.

Hard water - Generally defined as water containing 332 ppm of calcium carbonate. Water that contains certain minerals, usually calcium and magnesium sulfates, chlorides, or carbonates, in solution in sufficient amounts to cause a curd or precipitate instead of a lather when soap is added. Very hard water may cause precipitates in some pesticide sprays.

Hazard - The probability that injury or detrimental effects will result if a substance is not used properly.

Herbaceous plant - A vascular plant that remains soft or succulent and does not develop woody tissue.

Herbicide - A chemical used for inhibiting the growth of or killing plants.

High volume sprays - Spray applications of more than 60 gallons per acre volume.

Homolog - A series of compounds which express similarities of structure but have different formula.

Hormone - A naturally occurring substance in plants or animals that controls growth or other physiological processes. It is used with reference to certain man-made or synthetic chemicals that regulate or affect growth activity.

h.p. - Horsepower.

Humidity - Refers to the dampness or amount of moisture in the air.

Hydrated - The addition of water.

Hydrocarbon - Chemicals that contain carbon and hydrogen only.

Impermeable - Not capable of being penetrated.

Incorporate into soil - The mixing of a pesticide into the soil by mechanical means.

Inert ingredient - That part of a compound without toxic or killing properties sometimes called the carrier.

Infection - The development and establishment of a pathogen in its host which will produce a disease.

Ingested - Taken into the digestive system.

Inhibit - To hold in check or stop.

Inorganic compound - Those compounds lacking carbon.

Insect - Animals distinguished in the adult stage by a body divided into three regions - head, thorax and abdomen; and the thorax divided into three segments each bearing a pair of legs.

Insecticide - A compound or mixture of compounds used to prevent, destroy or repel insects.

Integrated control - Utilizes multiple approaches for pest control, giving consideration to minimum pesticide use.

Invert emulsion - A mixture in which oil is the continuous phase and water is dispersed in it.

Ionic surfactant - One that ionizes or dissociates in water.

Isomers - Two or more compounds having the same chemical composition but possessing different properties.

Knapsack sprayer - A light sprayer constructed to fit the back or be carried by the operator.

Jointing stage - When the internodes of grass stems are elongating.

Label - All written, printed or graphic matter on or attached to pesticide containers as required by law.

Lactation - Animals producing milk.

Larvae - The growing worm-like stage of insects which go through metamorphosis.

Latent period - Dormant period.

Lateral movement - Chemical movement in a plant or in the soil to the side or horizontal movement in the roots or soil layers.

Lay-by treatments - Applications of pesticides after the last cultivation.

LC_{50} - Means of expressing the lethal concentrations of a compound in air as a dust, mist, gas or vapor. It is expressed as micrograms per liter as a dust or mist, but in the case of gas or vapor as ppm. The $L.C._{50}$ is a statistical estimate of the dosage necessary to kill 50% of a test animal population.

Leaching - The downward movement of a substance in solution through the soil.

Leaf blade - The flat portion of a leaf.

Lethal - Fatal or deadly.

Low-volatile ester - An ester compound with a high molecular weight and a low vapor pressure such as butoxy-ethanol, iso-octyl, or propylene glycol butyl ether esters.

Low volume spray - A spray application of 5 to 20 gallons per acre.

Maggot - Larval stage of flies.

Metamorphosis - Any change in form or structure of an insect during the growing period.

Microfauna - Microscopic forms of animal life.

Microflora - Microscopic forms of plant life.

Miscible liquids - Two or more liquids capable of being mixed uniformly and under normal conditions remain mixed.

Mist blower - Spray equipment in which hydraulic atomization of the liquid at the nozzle is aided by an air blast past the source of spray.

Miticide- A chemical used to control mites (acarids).

Molluscicides - Chemicals used to control or kill slugs and snails.

Monocot - A seed plant having a single cotyledon (monocotyledon) or leaf; includes grasses, corn, lilies, orchids and palms.

Morbidity - The relative incidence of disease or the state of wasting away.

Mosaic - A virus type plant infection showing patchwork of discolored areas on a leaf.

Mutagenic - Capable of producing genetic damage.

Necrosis - Death of a tissue, such as in a designated portion of a plant.

Nematocides - Compounds used to control or kill nematodes.

Nematodes - Microscopic round worms which can cause considerable crop damage.

Neutral soil - A soil neither acid or alkaline, having a pH of 7.0.

Nonionic surfactant - Chemically inert.

Non-selective herbicide - Herbicide formulations which in general are toxic to all plants without regard to species.

Noxious weed - A plant defined by law as being especially undesirable troublesome, or difficult to control.

Nutrient - In reference to plants, a chemical taken into the plant that is essential for its development.

Nymph - The early stage in the development of insects which have no larva stage.

Oils - Usually refers to aromatic or parafinic oils used as diluents in formulating products as carriers of pesticides or for direct use.

Oral toxicity - Toxicity of a compound when it is ingested.

Organic compounds - Chemicals made up with molecules of several carbon atoms.

Organophosphate - An organic compound containing phosphorous such as malathion, parathion etc.

Overall treatment - Application uniformly over the entire area.

Ovicide - A substance used for killing eggs of insects and mites.

Parasite - An organism that lives in or on some living plant or animal and obtains part or all of its nutrients from it.

Pathogen - The infective agent causing a disease such as a fungus, a bacterium, or a virus.

Penetrant - Wetting agents that enhance the ability of a liquid to enter into the pores of a substrate.

Perennial - A plant that lives for more than two years.

Pesticide - Any substance or mixtures of substances used to control or kill insects, rodents, weeds, fungi, and other pests.

Pesticide tolerance - The amount of pesticide residue which may legally remain in or on a food crop.

Petroleum distillate - Kerosene.

pH value - The degree of acidity or alkalinity. The pH scale is from 0-14, with a value of 7.0 being neutral. Values below 7.0 indicate acidity with its intensity increasing as numbers decrease. Conversely, pH values above 7.0 indicates alkalinity with its intensity increasing as the number increase.

Photosynthesis - The process by which carbohydrates are manufactured by chlorophyll-bearing cell granules or chloroplasts (in green plants) from carbon dioxide and water using light as an energy source.

Phytotoxic - Poisonous or injurious to plants.

Plant pathology - The study of plant diseases.

Post emergence treatment - Application of pesticides after crop plants emerge from the soil.

Post harvest - Application of a pesticide to the soil or plant after crops have been harvested.

Potentiate - To augment, increase or improve the activity, utility or effectiveness of a compound for a given purpose.

Preemergence treatment - Application of pesticides after planting but before the crop emerges.

Preplanting treatment - Application made before the crop is planted.

psi - Pounds per square inch.

Pubescent - In reference to hair on plants.

Rate - Same as dosage. It is the amount of active ingredient material applied to a unit regardless of percentage of chemical in the carrier.

Reentry interval - The length of time between the pesticide applications and entry into the field to conduct hand labor.

Registered - Pesticides that have been approved for use by the Environmental Protection Agency.

Repellant - A compound that is unpalatable, unpleasant or annoying to a certain organism.

Residual - A compound that persists or continues to have activity against specific forms of plant and animal life.

Residue - The amount of pesticide that is on or in the crop at the time an analysis is made.

Residue tolerance - The amount of pesticide residue which may legally remain in or on a food crop.

Resistance - The degree to which an organism may suppress or retard the injurious effects of a pesticide.

Rhizome - Underground root-like stem that produces roots and leafy shoots.

Rodenticide - A compound used to destroy or control rodents and similar small animals.

rpm - Revolutions per minute.

Seed protectant - A chemical applied to seed before planting to prevent seed decay and damping off of new seedlings.

Seedling stage - Early stage of plant growth, technically prior to the development of a root system other than the seed or seminal root.

Selectivity - A characteristic of some pesticides, whereby certain undesirable species are killed while others such as crop plants or beneficial insects are harmed very little.

Sensitivity - Not capable of withstanding effects of a pesticide.

Slurry - A thick suspension of a finely divided substance in a liquid.

Soil application - Application of chemical made primarily to the soil surface rather than to vegetation.

Soil injection - Mechanical placement of the pesticide beneath the soil surface with a minimum of mixing or stirring.

Soil sterilant - A soil applied herbicide which prevents growth or establishment of plants temporarily or for long periods of time.

Solubility - The amount of a substance which will dissolve in a given amount of liquid substance.

Solvent - A liquid such as water, oil or kerosene used to dissolve other materials such as pesticides.

Species - A subdivision of a genus. A group of closely related individuals descending from the same stock.

Spot treatment - The application of a pesticide to a selected individual area.

Spreading agent - A substance to improve the wetting, spreading or possibly the adhesive properties of a spray.

Stolon - The above ground runners or slender stems that develop roots and shoots and new plants at the tip or nodes.

Stomach poison - Compounds that kill organisms when they are eaten and absorbed through the alimentary tract.

Stunting - In reference to plants, the retarding effect of growth and development.

Subacute toxicity - Results produced in test animals of various species by long term exposure to repeated doses or concentrations of a substance.

Surface tension - Due to surface molecular forces, a drop of liquid tends to form an apparent membrane that causes it to ball up rather than spread as a film.

Surfactant - A material used to improve the emulsifying, dispersing, spreading, wetting and other surface modifying properties of pesticide formulations.

Suspension - A liquid in which very fine solid material is suspended, but not dissolved.

Synergism - Compounds working together to produce an effect greater than the sum of their individual actions.

Synthesis - A process of building up a compound by combining simpler compounds or elements.

Systemic - Any compound that, when absorbed into one part of an organism, becomes distributed throughout.

Teratogenesis - Structural abnormalities of prenatal origin, present at birth or manifested shortly after.

Tolerant - The ability to withstand the effect.

Toxic - Poisonous, injurious to animals and plants through contact or systemic action.

Toxicity - The degree to which a substance is poisonous.

Translocation - The movement of a chemical from the point of absorption (plant leaves, or stems and sometimes roots) to other leaves, buds or root tips. Translocation also occurs in animals treated with certain pesticides.

Turbidity- Suspended material in water.

ULV - Ultra low volume - the application of a pesticide in a relatively pure form without or very little dilution. Total volume rates are usually 1/2 gallon or less per acre.

Vapor drift - The movement of pesticide vapors from the area of application to other areas.

Vapor pressure - The property which causes a chemical compound to evaporate.

Vector - A carrier such as an insect that carries or transmits a pathogen.

Virus - A sub-microscopic pathogen that requires living cells for growth and is capable of causing disease in plant or animals.

Viscosity - Measures the resistance of a liquid to flow.

Volatile - A compound is said to be volatile when it evaporates or is vaporized (changes from a liquid or solid to a gas) at ordinary temperatures on exposure to air.

Waiting period - The time interval (days) between application and harvest which will insure conformance with residue tolerances.

Water soluble powder - A finely ground pesticide powder which will dissolve in water.

Weed - A plant out of place or growing where not desired.

Weed control - The process of limiting weed infestations so that crops can be grown profitably or other operations can be conducted efficiently.

Weed eradication - The elimination of weeds from an area.

Wettable powder - A powder that will form a suspension in water, but is not soluble.

Wetting agent - A compound that when added to a spray causes the liquid to spread, increasing contact area with plant surfaces.

SECTION IX

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